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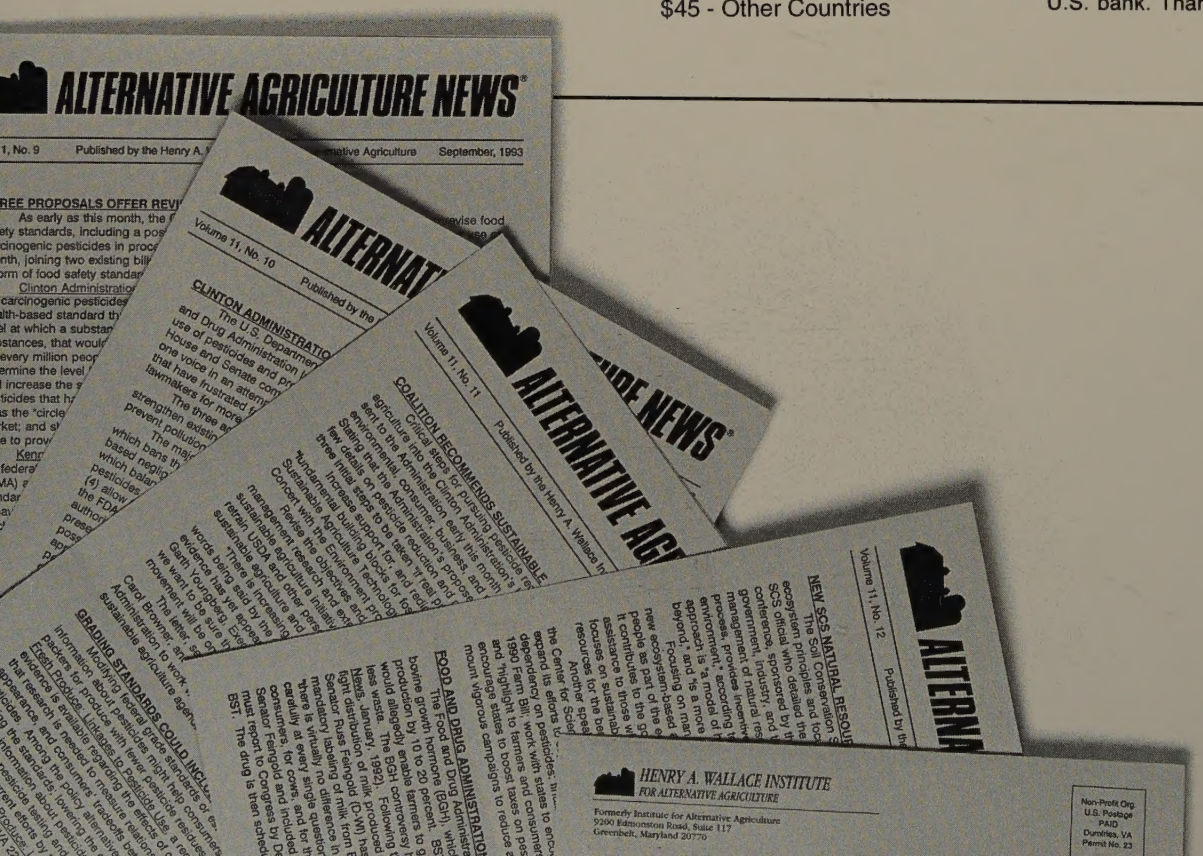

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AMERICAN JOURNAL OF ALTERNATIVE AGRICULTURE®

1998
Volume 13, Number 2

TABLE OF CONTENTS

Articles

50 **Constant Goal, Changing Tactics: A Wisconsin Dairy Farm Start-up** • Joshua L. Posner, Gary G. Frank, Kenneth V. Nordlund, and Ronald T. Schuler

61 **Feedlot manure nutrient loadings on South Dakota farmland** • Donald C. Taylor and Diane H. Rickerl

69 **Organic vegetable production in the U.S.: Certified growers and their practices** • Jorge Fernandez-Cornejo, Catherine Greene, Renata Penn, and Doris Newton

79 **Natural terrace formation through vegetative barriers on hillside farms in Honduras** • Robert J. Walle and Brian G. Sims

83 **Erosion effects on soil moisture and corn yield on two soils at Mlingano, Tanzania** • A.J. Tenge, F.B.S. Kaihura, R. Lal, and B.R. Singh

90 **Taking a pragmatic behavioral approach to alternative agriculture research** • Leslie Aileen Duram

Departments

Institute News—68 • Upcoming Events—96 • Resources—96

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Its programs include providing a national information clearinghouse, serving as a voice for sustainable agriculture in Washington, and developing and implementing research and educational outreach programs. It holds an annual scientific symposium and publishes a monthly newsletter.

The Institute is governed by a grass roots Board of Directors, which includes several commercial-scale organic farmers, and maintains a small professional staff. It is supported by memberships and donations and grants from foundations, corporations, and individuals.

Cover Photo

Heifers on pasture on the Krusenbaum alternative dairy farm in Wisconsin. Pasture supplies much of the dairy herd's feed, and does not require major chemical inputs. Photo supplied by A. Krusenbaum through J. Posner, University of Wisconsin-Madison.

Constant Goal, Changing Tactics: A Wisconsin Dairy Farm Start-up

Joshua L. Posner, Gary G. Frank, Kenneth V. Nordlund, and Ronald T. Schuler

Abstract. *This case study documents the start-up of a successful alternative dairy farm in Wisconsin. Initially the vision was to establish a 97-ha biodynamic farm with dairy and cash cropping. Low milk prices throughout most of 1991 and the heavy work load associated with conventional dairying forced the farm family to look for alternative strategies. They experimented with management-intensive grazing in 1992, and by spring 1994 had seeded their entire farm to sod. The work load still was too heavy, so they switched to seasonal dairying and outwintering of their dry stock, which reduced the daily midwinter work load from 12 to 3.5 hours. By the end of 1995, yearly net farm income from operations had risen from $21,500 (1990 and 1991) to $54,000 (1994 and 1995). The farm family, with its alternative approach (biodynamic, grass-based, seasonal milking) weathered the stresses of entering dairy farming at a time when entry rates were very low and existing dairy farmers faced substantial financial pressure. The grass-based system required low purchased feed inputs ($300 per cow) and nearly reached equilibrium in the whole-farm nutrient budget. Good herd management has maintained high productivity (rolling herd average of 17,000 lbs) and excellent herd health. Renting the farm and managing money carefully have resulted in a low debt load ($73 per cow). This study illustrates the complexities and adjustments associated with the initiation of an alternative farm business.*

Key words: case study, management-intensive grazing, seasonal dairying, biodynamic agriculture

This is the story of a family that successfully started an alternative dairy farm during a period of intense financial stress in Midwestern dairying. In March 1990, when the Krusenbaum family began farming, Wisconsin had about 33,800 dairy farms. By the spring of 1996, there were just 26,000 left, a decline of 23% (WASS, 1996a). Contrary to popular perceptions, however, the accelerated loss of dairy farms has not been caused by a rising rate of farmers being forced out of business (Jackson-Smith, 1996). Rather, the crisis has been caused largely by a decline in the number of young people willing and able to start out in the dairy business (Jackson-Smith, 1994; Jackson-Smith and Barham, 1996).

The Krusenbaums entered an industry in crisis, and weathered the exceptionally low milk prices of 1991. By the end of 1995 they were meeting their personal goals of enjoying farming, having a decent standard of living and being good stewards of the land. They could do this using an approach (low-input, pasture-based, seasonal milking) that is contrary to the dominant trends in U.S. dairying. The sector of the dairy industry that is expanding is characterized by very capital intensive, larger-than-family size, full confinement operations (Perez, 1994; Smith, 1994). An obvious problem with this approach to dairying, however, is that it is beyond the economic reach of most beginning farmers.

In the winter of 1990, Altfrid and Sue Krusenbaum leased a 97-ha dairy and cash grain farm in southeastern Wisconsin with the dream of gradually converting it to biodynamic operation. Altfrid came to this task after working five years at a biodynamic dairy, and Sue was raised on a neighboring biodynamic dairy farm. Even more than organic agriculture, where the emphasis is on chemical-free production, biodynamic agriculture gives high priority to a holistic vision, where the goal is to develop a nearly closed system of nutrient cycling and energy use through intensive recycling of organic matter and the integration of crops and animals (York, 1997).

A team of researchers entered a collaboration with the Krusenbaums during the start-up year to monitor their progress (Stevenson et al., 1994). We describe the first six years (1990-1995) in three phases: 1) the "Start-up Phase" (1990 and 1991); 2) the "Early Phase" (1992 and 1993), which introduced them to management-intensive grazing; and 3) the "Intensive Phase" (1994 and 1995), during which the entire farm was seeded to grasses and legumes and converted to seasonal dairying. Three broad sets of variables—crop production and land stewardship, herd health and production, and economic performance—are then examined in characterizing the evolution of this farm's production system. Wherever possible, we compare the performance during the most recent

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period with industry benchmarks derived from other data sets. A decision diary kept by the Krusenbaums provides insight into key management issues at different stages of the farm's evolution.

The Krusenbaums started with a plan to establish a mixed farm that included dairying, cash crops, tree crops, and vegetables. Low milk prices in 1991 tested their commitment to establishing a farm, but they decided to continue and increase the size of the dairy from 37 to 45 cows (Fig. 1). The long hours required to manage the herd and fields, and the need for Sue to spend most of her time with their young children, led them to search for a more labor-efficient system. In 1992 they experimented with management-intensive grazing on 14 ha, which they expanded in 1993 to 25 ha. By the beginning of 1994, they were committed to eliminating their row crops and employing management-intensive grazing exclusively. They calculated that to make the best use of their pastures they would have to increase herd size again, from 45 to 70 cows. To insure that they would have vacation time, they would move to seasonal dairying. The conversion to seasonal dairying required that they sell the cows that would not deliver their next calf during the short calving season, and buy replacement cows.

To reduce the work load further, they would keep the herd outside during the winter. Traditionally, dairymen have put their animals out during the day for much of the winter, but "outwintering" means having the animals out of the barn throughout the winter, except for milking. While this reduces the work load (hauling manure), it requires careful management in moving the animals, getting them feed and water, and protecting them during the coldest weather. In an attempt to increase their flexibility in putting up forage from the paddocks and feeding the outwintering animals, the Krusenbaums sold their now unneeded row crop machinery and invested in equipment to make round bales and "balage" (hay ensiled in plastic-wrapped bales). By the end of 1995, the farm was entirely in sod, milk production was good, and the family, now with three young children, was making money. Net Farm Income from Operations (NFIFO) had grown from $21,500/yr during the start-up phase (1990 and 1991) to $54,000/yr in the intensive grazing phase (1994 and 1995).

Literature Review

Previous research on alternative farming strategies has focused either on monitoring already established farms or on using modeling techniques to predict the economic effect of alternative production strategies. For example, the literature contains "across-the-fence" comparisons of conventional and organic farms regarding soil characteristics (Reganold, 1988; Reganold et al., 1993; Nguyen et al., 1995), energy use, and labor inputs (Karlen et al., 1995; Nguyen and Haynes, 1995). Other studies have addressed the relative profitability of alternative farming strategies (Lockeretz et al., 1981; Batte et al., 1993). In addition, some researchers have presented detailed case studies on established organic growers to explain how successful systems work (Culik et al., 1983; National Research Council, 1989). Taking another approach, some researchers have constructed model farms and estimated the economic effects of introducing soil conserving rotations (Dabbert and Madden, 1986) or rotational grazing (Frank et al., 1995). These reports generally show favorable results for alternative practices. However, few studies have addressed whether in today's market a family can successfully start a farm based on alternative farming practices.

The Setting

The Krusenbaum's cash grain and dairy farm in southeastern Wisconsin has a rolling karst topography, with soils that are predominantly silt loams. In the mid-1960s, the previous owner's son decided not to go into dairying, so the investment emphasis shifted away from the herd toward developing a less labor-intensive cash grain operation. As a result, only enough alfalfa (*Medicago sativa*) and oats (*Avena sativa*) were grown to supply the forage needs of 38 Holsteins, with the rest of the farm planted to corn (*Zea mays*) and wheat (*Triticum aestivum*). By 1990, the farm had a 50-ha ASCS corn base, a 5-ha wheat base, a serious problem of erosion (see Table 1, row 10), and a history of heavy atrazine use. Their rental arrangement with the new owners of the farm, a couple dedicated to promoting biodynamic agriculture, was that besides paying rent, the couple would be responsible for building and fencing repairs. As a result, their lease has averaged about $19,000/yr. The land base included 81.8 ha of tillable land, which was divided into six large fields (Fig. 2a), and 12.1 ha of permanent pasture and woods.

Methods

The study team used several tools to monitor developments on the Krusenbaum farm. The Krusenbaums kept a diary to record crop production activities, yields, and cattle movement on the paddocks. They kept a weekly labor diary in 1992 and 1993, and since the start of the project have maintained a decision diary on the logic behind all financial decisions involving more than $500. The monitoring team took samples to estimate soil fertility, weed seed load, paddock productivity and forage quality, and nutrient concentrations of manure and feeds. To estimate soil erosion, machinery costs, and farmgate nutrient budgets, the team collected data used in existing computer programs (USDA-SCS, 1987; Lanyon and Schlauder, 1988; Schuler and Frank, 1991). Annual economic analysis was done at the same time as tax preparation by Altfrid and the team, with the aid of the Agricultural Accounting and Information Management System (AAIMS) (Frank, 1993). Standard herd production data were collected and maintained in official records by the Dairy Herd Improvement Association of Wisconsin.

Agronomic Performance

To meet their objective of establishing a biodynamic farm, the Krusenbaums and the project team saw their initial challenges to be reintegrating the cash grain and dairy rotations, improving nutrient management on the farm, and reconfiguring the fields to reduce erosion.

Using the land to feed the herd

1. The start-up phase. During the start-up years 1990 and 1991, because of the previous heavy use of atrazine on the farm (4.4 kg a.i./ha) and the need to protect

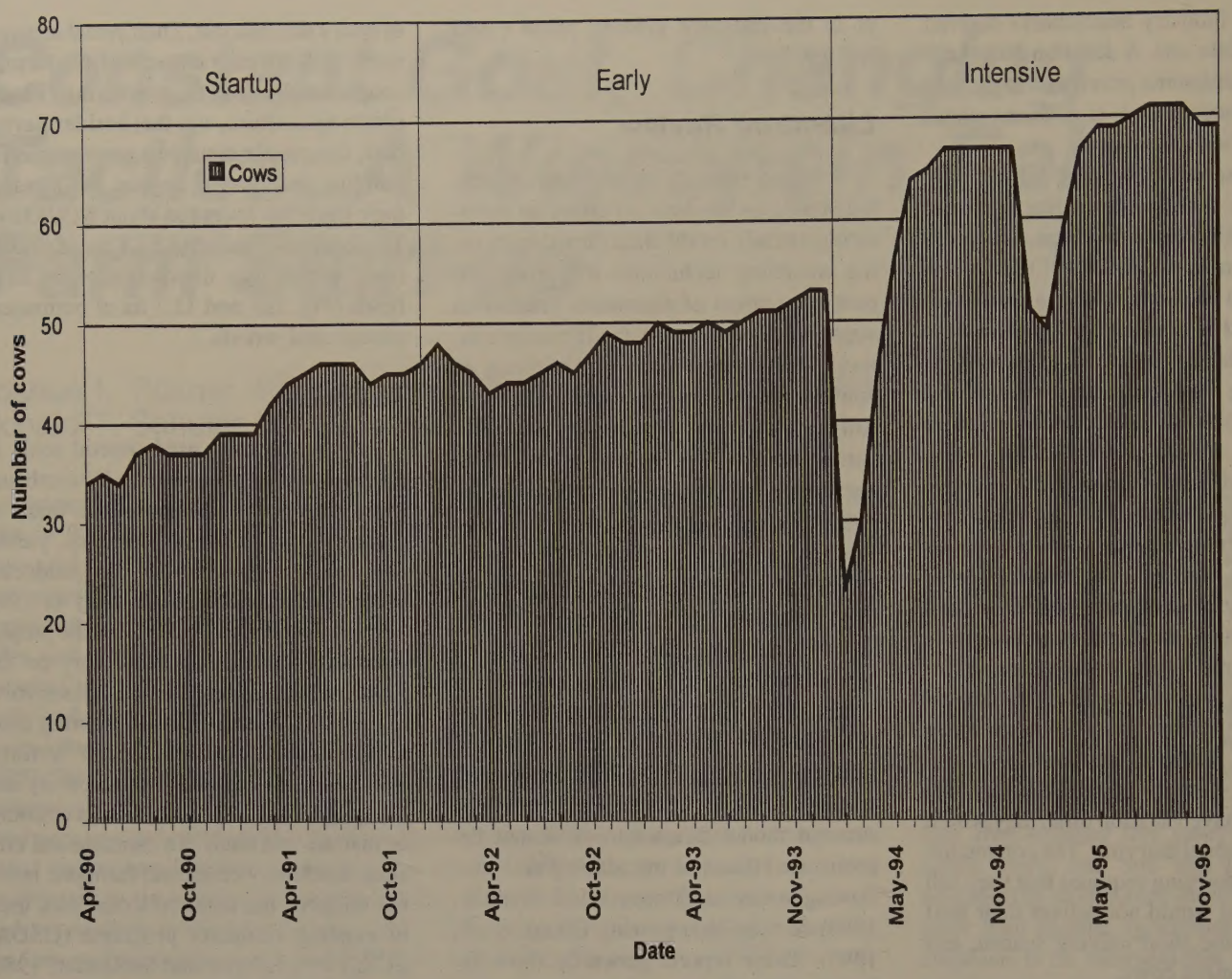

Figure 1. Evolution of Cow Numbers on the Krusenbaum Farm

their corn base, the Krusenbaums had little cropping flexibility. However, by the second year, in consultation with the research team Altfrid set up two concurrent rotations, one with more row crops for the more level fields, the other with a longer sod rotation for the slopes (Fig. 2b). By adding 12 ha of soybeans (*Glycine max*) to the basic oat-hay-corn rotation, it was possible to meet base-acre requirements without having to plant corn after corn. During these first two years, their plan was to sell crops from 20 ha and to use the remaining tillable area (60 ha) to feed the herd.

Although pressure from foxtail (*Setaria* spp.) was heavy, the Krusenbaums immediately eliminated the use of herbicides, relying on rotary hoeing and cultivation for the 45 ha of row crops. Superimposed strips with additional hand weeding showed that yield losses due to weed competition in 1990 and 1991 were modest (8-10%) (Doll, 1992). However, where corn was to be planted after corn in 1990, soil insecticides were used to limit damage from root worm (*Diabrotica* spp.) and lodging. Yield monitoring by the team showed that row crop production was below average, while hay yields were good (Table 1, rows 1 and 2). Farm production met most of the herd's protein and energy needs, and feed purchases averaged only $300 per cow. This compares favorably to typical purchased feed costs in Wisconsin of almost $500 per cow (Table 1, row 5). This was primarily due to the low stocking rate on the farm (2.2 ha of land per cow) during the start-up phase. Not surprisingly, crop sales were an important part of farm income during the first phase (Table 1, row 6).

A major cost component with the conventional strategy, using stored feed, is field machinery. Typically, machinery costs are 20 to 25% of total production costs (Petritz et al., 1987). The Krusenbaums began with a typical complement of equipment in 1990 and supplemented it with a Buffalo cultivator and guidance system to help with mechanical weed control on the contour strips. Machinery costs on the farm were estimated using purchase price, area covered, and maintenance costs (Schuler and Frank, 1991). During this first period, estimated machinery costs (fixed + variable) were $163/ha (Table 1, row 7). The benchmark figure of $253/ha is based on the use of new machinery, and therefore overestimates machinery costs on most dairy farms.

The start-up phase was financially difficult for the Krusenbaums. The drop in

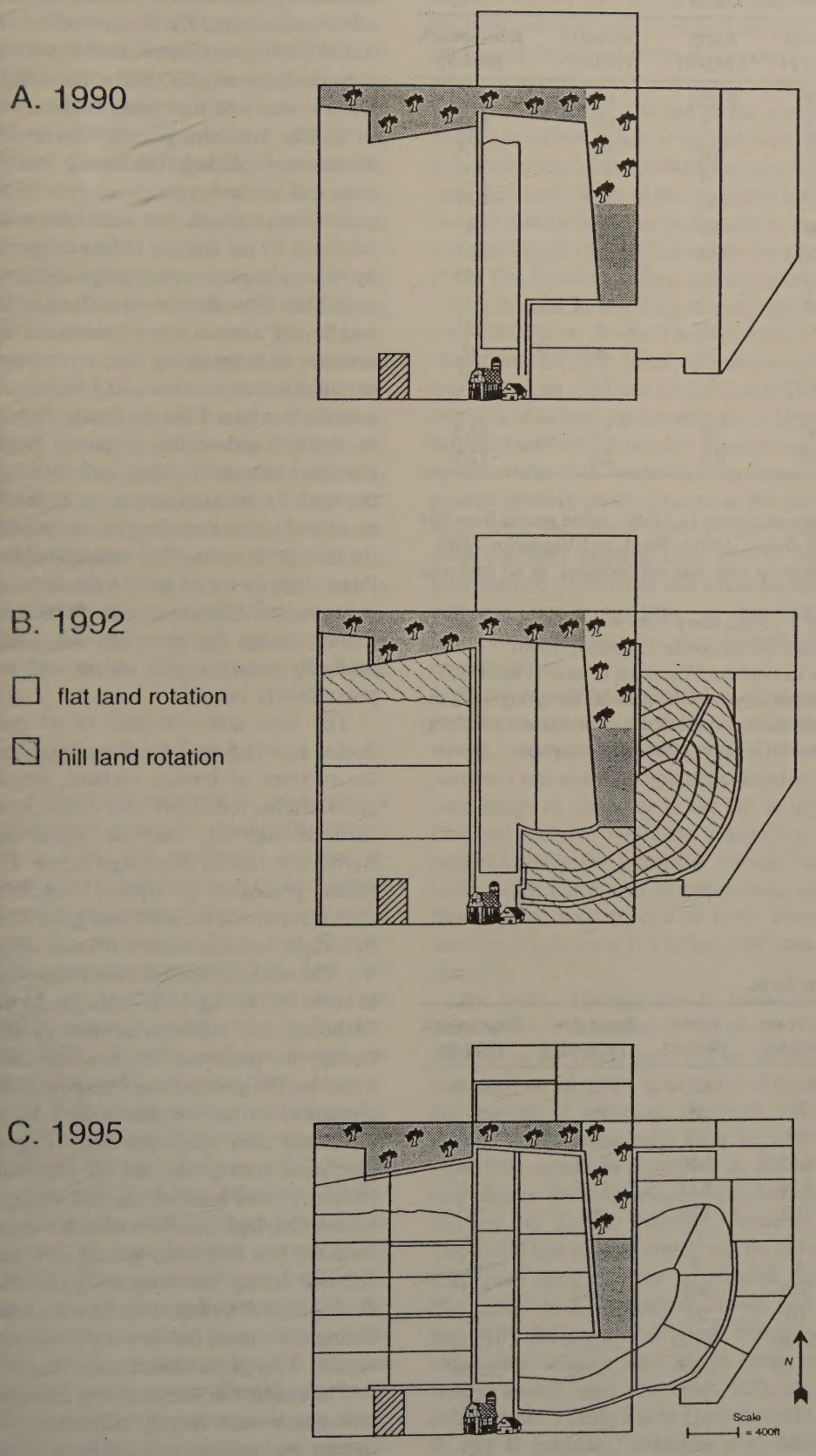

Figure 2. Changing Field Configuration on the Krusenbaum Farm (1990-1995)

milk prices from $0.315/kg to $0.24/kg in fall 1990 reduced the monthly milk check from $8,200 to $6,400. Prices remained low throughout 1991; although the Krusenbaums were concerned, they decided to increase the herd to 48 and remain on the farm.

2. The early phase: Introduction to management-intensive grazing. In winter 1992, Altfrid attended a regional grazing conference and decided to experiment with management-intensive grazing as a partial solution to his labor and financial problems. Initially he set up eight paddocks on 14 ha, which cost about $3000 (fencing plus water system). The following year, this was expanded to 14 paddocks on 25 ha. Milk production remained high during this early phase (Table 2, row 1), as feed from the paddocks was supplemented in the barn with 7 kg of corn silage per cow per day, 10 kg of corn grain, and from 0 to 2.5 kg of cotton seed or soybean meal, depending on production level.

A primary concern during this phase was learning how to move the animals to maintain forage quality. However, weekly sampling by the team in 1992 and 1993 showed that good quality forage was available throughout the season (Relative Feed Value = 120-200, Crude Protein = 15-28%, mean of 45 samples). Calculating backward from milk production, feed supplements, and stocking rates, we estimated that the paddocks in 1992 and 1993 were producing approximately 8 t of dry matter/ha, which compared favorably with the fields that were only cut for hay (Table 1, rows 2 and 3). Grazing reduced the cost of feeding the herd, and although the stocking rate had increased (land per cow down to 1.8 ha), purchased feed per cow dropped to $282, or about 53% of the average costs incurred by dairies in the AAIMS monitoring program in 1992 and 1993 (Frank, 1994; 1995a).

Although the herd was now harvesting much of the feed itself, machinery costs did not decline substantially (Table 1, row 7). As other studies have shown, dairymen moving toward management-intensive grazing initially keep their full complement of field equipment although the area in row crops decreases (Schuler et al., 1994). Owning and maintaining machinery is costly. Also, the usually smaller equipment associated with dairy farming

Table 1. Agronomic performance on the Krusenbaum farm.

Agronomic Variable	Start-up 1990-91	Early 1992-93	Intensive 1994-95	Benchmark 1994-95
1. Corn yield (kg/ha)	6,000	6,950	NA	8,310[1]
2. Alfalfa yield DM (t/ha)	7.75	7.5	NA	7.23[1]
3. Pasture yield DM (t/ha)	NA	8.0	8.0	NA
4. Stocking rates (ha/cow)	2.2	1.8	1.3	1.5[2]
5. Purchased feed ($/cow)	300[3]	282	325	490[2]
6. Crop sales ($/ha)	110	65	10	88[2]
7. Machinery costs ($/ha)	163	148	155	253[4]
8. Agricultural chemicals ($/ha)	7.60	0	0	28[2]
9. Farmgate nutrient budget (kg/ha)				
a. N	37	-10	1	22[5]
b. P	8	2	6	7[5]
c. K	28	8	11	27[5]
10. Soil erosion (t/ha)				
Hilly zone (8%)	21.3[6]	10	3.0	12.5
Level zone (3%)	11.8[6]	8.8	2.5	12.5

[1] Walworth County data (WASS, 1996b).
[2] Agricultural Accounting and Information Management System (AAIMS), mean results from 904 dairy farms in 1994 and 934 dairy farms in 1995 (Frank, 1995b; Frank and Vanderlin 1996).
[3] Purchased feed calculation only for 1991. The start-up year was not included, as all feed was purchased until the first alfalfa harvest in June.
[4] Assuming an average equipment complement for a 120-ha dairy farm with 50% of the area in hay and 50% in new seedings and row crops (Univ. of Wisconsin-Extension, 1996).
[5] Farm gate budget from survey of 19 dairy farms in southern Wisconsin (Fisher et al., 1996).
[6] Estimated soil loss with previous owner's tillage and crop rotation pattern. By spring 1992 the new rotation and contour strips were in place and estimated erosion had decreased. 12 t/ha is the accepted tolerance for soil loss on a McHenry silt loam in southern Wisconsin.

Table 2. Herd performance on the Krusenbaum farm.

Herd Production Indicators	Start-up 1990-91	Early 1992-93	Intensive 1994-95	Benchmark 1994-95
1. Rolling Herd Average (lb/yr)	16,853[2]	18,354	17,114	18,646[1]
2. Days in milk (%)	85	84	84	84[1]
3. Days dry per year	57	67	83	63[1]
4. Milk fat (%)	3.55	3.50	3.18	3.82[1]
5. Milk protein (%)	3.16	3.15	3.15	3.18[1]
6. Veterinary costs per cow ($/yr)	102	126	86	76[3]
7. Annualized culling (%)	16	27	56	37[1]
8. Dairy cow sales as % of all cows sold	0	9	81	14[4]
9. Price for cows sold ($/cow)	635	646	1,125	531[5]
10. % of herd sold as involuntary culls	16	24	11	34[4]
11. Cull cow sales ($/yr)	5,720	6,790	29,820	11,488[3]
12. Calf sales ($/yr)	3,160	3,200	3,280	5,566[3]
13. Somatic cell count (10^3/ml)	234	317	181	322[1]
14. Average days open per year	110	113	101	130[1]
15. PTA$ (deviation from norm)	–24	+11	–43	0[1]

[1] Reference values, Wisconsin DHIA, All Holstein Herds, December, 1995 and 1996.
[2] Because RHA requires 12 months of data, this represents RHA from April-Dec 1991.
[3] Calculated from data in WASS (1991, p. 18).
[4] WASS (1996a, p. 30).

(for example, a four-row planter) often has a low resale value. The Krusenbaums' initial $65,000 investment in used machinery brought them only $35,000 at the auction when it was sold four years later.

3. The intensive phase: Conversion to seasonal milking. The family was encouraged by the economic success of the grazing experiment, but remained overwhelmed by the amount of labor required by their split system (row crops and grazing). Their labor diary showed that grazing and haying were as labor intensive in the summer as maintaining the conventional oat-alfalfa-corn rotation (10.7 hr/ha). As a result, in winter 1994 the family decided to establish sod on the remaining fields, introduce seasonal calving, and outwinter the herd. To take full advantage of the 88 ha of paddocks, they decided to increase the herd to 70 cows. They anticipated that these changes would reduce the stress of doing several different crop production activities during the summer, and would markedly reduce winter chores and improve family income.

The farm now consisted of 47 paddocks, each 1.5 to 2 ha (Fig. 2c). Since the mixture of brome, orchard, quackgrass, alfalfa, red clover, and white clover (*Bromus inermis, Dactylis glomerata, Agropyron repens, Medicago sativa, Trifolium pratense, T. repens*) had been shown to provide the herd with good quality forage, the focus shifted to forage quantity. The stocking rate has been maintained at about 50,000 kg of animals per ha per 24 hours, and regrowth permits cycling through the paddocks five to seven times a season. The grazed forage has been complemented in the summer with 7 kg of purchased corn silage per cow, 9 kg of purchased corn grain, and no additional protein. Round bales of hay and wrapped bales of haylage that have been harvested from the less frequently grazed paddocks are fed during the nongrazing months. During their daily trip to the barn for water during the winter, the now dry cows each receive 7 kg of purchased corn silage.

The changes in tactics during the intensive phase were largely successful. Although the stocking rate almost doubled, with land per cow down to 1.3 ha from 2.2 ha in the start-up phase, purchased feed costs remained low ($325 per cow). This shows that the pasture has continued to

supply most of the herd's energy and protein. The average cost of purchased feed on the Krusenbaum farm is 66% that of dairies in the large sample of farmers using the AAIMS program (see Table 1, row 5; Frank, 1995b; Frank and Vanderlin, 1996). Also, daily labor requirements during the winter months (January-February), when the herd was dry and outwintered, dropped from 12 to 3.5 hr.

Although one would expect machinery costs to decline with the shift to grazing, this has not been the case. The Krusenbaums wanted a system that permitted high quality harvests from the small, ungrazed paddocks and that gave them flexibility in feeding the outwintering animals. Instead of upgrading their tower silo, they decided to make round bales in the paddocks, and wrap some as balage. Unfortunately, custom baling was not available in southeastern Wisconsin, so they had to buy their own equipment. These new investments ($48,000) kept machinery costs nearly constant over the first six years (Table 1, row 7).

Nutrient management

A crucial component in developing a biodynamic system is making efficient use of on-farm and purchased nutrient resources. To monitor the evolution of soil fertility, the research team laid out a soil sampling grid on the farm, and 32 sampling stations were identified. Soil tests (0-15 cm) in 1990 showed that the farm fields were very high in soil-test phosphorus (STP >90 ppm) and low in soil-test potassium (STK <90 ppm) (Bray-1 extraction). Soil pH (in water) ranged from 6.2 to 6.8. Organic matter levels were around 1.5% on the eroded slopes and 2.2-2.6% on the more level land (Harrison, 1993).

During the start-up phase manure was lacking, so some fertilizer was purchased (100 kg N/ha as urea for corn; 60 kg K/ha as potash for seeding oat/alfalfa). To avoid using fertilizer in the future, however, the Krusenbaums aimed to improve manure management. During the early phase, two changes were made in manure handling. The introduction of summer rotational grazing reincorporated onto productive paddocks the nearly 35% of the manure that was being deposited and "lost" on the overgrazed exercise lot. To improve further the capture of nutrients in the barn manure, they modified the daily hauling of fresh manure to stack compost piles. A grated sump and pump system was installed at the low end of the gutter cleaner to collect excess urine and pump it into an aboveground 50,000-liters second-hand fuel tank. Most of this "manure tea" had previously been lost on the trip to the composting pile or leached below the pile itself. The liquid contained approximately 1.8 kg of total K and 2 kg of available N per 1,000 liters. In the first full year of operation, 130,000 liters of manure tea was spread on corn and alfalfa fields. The move to outwintering the animals in 1994 further modified the manure management system. After that, winter manure was deposited directly on the pasture as the animals were fed round bales of hay, and rotated around the farm. Only 15% of the total manure stream was still available for collection and composting, so that little more could be done to improve manure management.

Green manuring met with less success. A mixture of hairy vetch (*Vicia villosa*), wheat, and perennial ryegrass (*Lolium perenne*) was sown on fields harvested for corn silage or soybeans in the fall in the first two seasons. While the grasses covered the fields the following spring, the hairy vetch catch was disappointing, so this practice was stopped in 1993. Frost seeding of red clover (13 kg/ha) continues, however.

By 1996, although soil K levels remained low (<90 ppm) at 20 of the 32 stations on the farm, there was no significant drop on 25 of the stations, even after six seasons of cropping, primarily with manure applications only. P on the other hand, has remained excessive at all but one station. Three-quarters of the stations showed no further increase, however. These soil test results, which mostly have remained constant, are confirmed by "farmgate" nutrient budgets. These budgets tally the transfer of feed, minerals, straw, hay, and fertilizer to the farm, as well as annual sales of animals, milk, and crops. Rows 9a-c in Table 1 report the N, P, and K balances, averaged over each two-year period. The farmgate balance is presented in area terms. Feed purchases were large in 1990 and 1991 during the start-up phase because of the need to build inventory, and crop yields were only modest. This resulted in larger levels of nutrient accumulation on the farm. During the early phase, the farm was close to equilibrium and had a 48-cow herd. During the intensive phase, however, P and K accumulated slightly more rapidly as the herd increased to 69 cows. These values show the Krusenbaum farm to be much closer to nutrient equilibrium than many dairy farms. In a case study of nutrient budgets from southeastern Pennsylvania, Lanyon and Beegle (1989) found annual nutrient accumulations of 141 kg N/ha, 9 kg P/ha, and 51 kg K/ha. In a recent survey of nineteen dairy farms in southern Wisconsin, average annual accumulation of P and K was estimated at 7 and 27 kg/ha, respectively (Fisher et al., 1996).

Land stewardship

Besides nutrient management, the Krusenbaums were very concerned about the high erosion rates they encountered during their first season on the farm (Table 1, rows 10a and b). Soil sampling showed that the cultivated knolls had only 30 cm of silt loam topsoil, while the depositional sites had nearly 60 cm of silt loam overlying the glacial till. Paired comparisons between the permanent pasture and "across-the-fence" cultivated sites showed that approximately 8 cm of topsoil had been lost since these areas were first cultivated after World War II. A visual evaluation showed that by 1990 the soils on the farm were eroded by at least one class more than they had been classified in a 1971 State Soil Survey map (L. Massie, Extension Specialist in Soil and Water Management, private communication, 1992).

To address these problems, the Krusenbaums reconfigured the fields by breaking out the most sloping land and putting it into contour strips, and by establishing permanent headlands and broadened the existing waterways (Fig. 2b). In total, they took 2 ha out of arable production to help control erosion, and by making smaller, contoured fields, reduced erosion on 16 ha of their steepest land. Estimated soil loss dropped dramatically during this period. With the completely sod-based system in the intensive phase, erosion has been almost halted (Table 1, row 10).

Herd Performance

Production

Milk production per cow has been nearly constant over the six-year period despite significant changes in herd management. Rolling herd average (RHA) is the standard way to monitor herd milk production, but unfortunately can be confounded by various management factors. RHA reached the highest point in the early phase (Table 2, row 1), and by the end of the intensive phase was only 7% lower than maximum production during the early phase, which relied on a combination of grazing and stored feeds.

There is a concern that conventional measures of herd production developed for confinement dairies do not accurately describe productivity in dairies using seasonal calving. It is commonly assumed that when a dairy sells and purchases cows to fit a calving season or window, the herd will have fewer cows in the dry period and the "percent days in milk" will increase, inflating the RHA. That did not occur here, as percent days in milk remained constant at about 85% across the three periods (Table 2, row 2). However, the average number of dry days increased from approximately 60 in the start-up and early phases to 83 in the intensive phase (Table 2, row 3). This seemingly paradoxical finding shows that shutting down the milking operation each winter increased the length of the dry period of the cows that were held over to the next calving season. Eliminating the dry days of the cows that were sold kept days in milk constant.

A better indicator of how different feeding methods affect milk production is the herd average Mature Equivalent (ME). Unlike RHA, herd average ME is not influenced by reproductive performance or dry period length. ME standardizes each cow's production by eliminating the effects of different lactation number, age at calving, season, and number of times milked per day. By tracking the herd average ME over time, nutritional management of the herd can be monitored closely. As seen in Figure 3, average ME climbed steadily through the start-up phase, peaked during the first winter and spring of the early phase, and declined modestly and stabilized through the intensive phase.

However, milk fat changed markedly when the herd switched to seasonal calving and intensive pasture management (Table 2, row 4). The milk fat of the Krusenbaum herd had been near the Holstein breed average of 3.5% fat, but decreased to an annual average of 3.2% with spring calving, for two reasons. First, the normal lactation milk fat curve starts high, reaches a minimum at 2 to 3 months, then gradually increases toward the end of the lactation. Second, milk fat also tends to be lower during the summer, independent of the stage of lactation (WASS, 1996a). With spring calving, the low milk fat typical of early lactation was superimposed on the fat-reducing effect of summer. These two factors also coincided with the highest milk volume in a seasonal system. The overall low milk fat during the intensive phase lowered the milk price by $0.20/cwt. With the current low value of milk fat, this effect amounts to a loss of milk revenue of slightly less than 2%. However, milk protein has remained stable across the three phases (Table 2, row 5).

Herd health

Common wisdom suggests that cow health improves when the herd moves from confinement housing onto pasture. However, this is very difficult to quantify because of issues of case definition. Annual veterinary bills per cow have remained somewhat high over the first six years (Table 2, row 6) and are above the AAIMS average. In the trade, the Krusenbaums are described as having a "companion" philosophy about their herd. They seek prompt diagnostic services and favor giving care that minimizes the animal's discomfort from disease or injury.

Perhaps the most reliable monitors of overall herd health are the disposition of cows culled from the herd and the somatic cell counts. Cows with injuries, diseases, or infertility will be sold from the dairy to the slaughter market for meat as "involuntary culls," accounting for about 86% of the cows sold from Wisconsin dairy farms each year (WASS, 1991). Slaughter cows are of low value, so dairy managers try to keep the cull rate low (about 25% of the herd annually; Rodgers et al., 1988). "Voluntary culls" can include both cows that are sold to slaughter markets because of lower production and higher-producing, healthy cows that are sold to other dairy farms as replacement cows. Cows sold to other dairies command a higher price than slaughter cows and account for about 14% of the cows sold annually from dairy farms (WASS, 1991). Dairy farms that improve their herds' health usually can reduce the annual cull rate to a low level, or they can sell sound, productive cows as dairy replacements.

The Krusenbaum dairy experienced lower than average culling rates during the start-up and early phases (Table 2, row 7). However, almost all the animals sold from the dairy went to slaughter markets because of various problems or low production. When the Krusenbaums shifted to seasonal calving in the intensive phase, they sold all cows that were not due to calve between April and June. This practice increased the overall cull rate to a very high level, but because most of the cull cows were sold to other dairy farms as replacements (Table 2, row 8), the average price received for them increased dramatically during the intensive phase (Table 2, row 9). The actual fraction of the herd sold as involuntary culls decreased during the intensive phase to about half the rate of the early and start-up phases (Table 2, row 10).

Mastitis, an infection of the mammary gland, is a common problem of dairy cows. White blood cells, also called somatic cells when they migrate into the mammary gland, increase in the milk when mastitis is a problem. Because Somatic Cell Count (SCC) can be measured in routine milk testing procedures, herd average SCC is commonly used to monitor the mastitis status of a dairy herd. The Krusenbaum herd experienced a desirable and below-average SCC during the start-up phase, an increase to average levels during the early phase, and a drop to excellent levels during the intensive period (Table 2, row 13). Because SCC status is the result of many factors, including milking machine function, milking practices, cow environment, current infection prevalence, and resistance of the cow, the excellent SCC records from the intensive phase cannot be credited only to intensive grazing and seasonal calving. However, the herd records show that despite purchasing many new cows

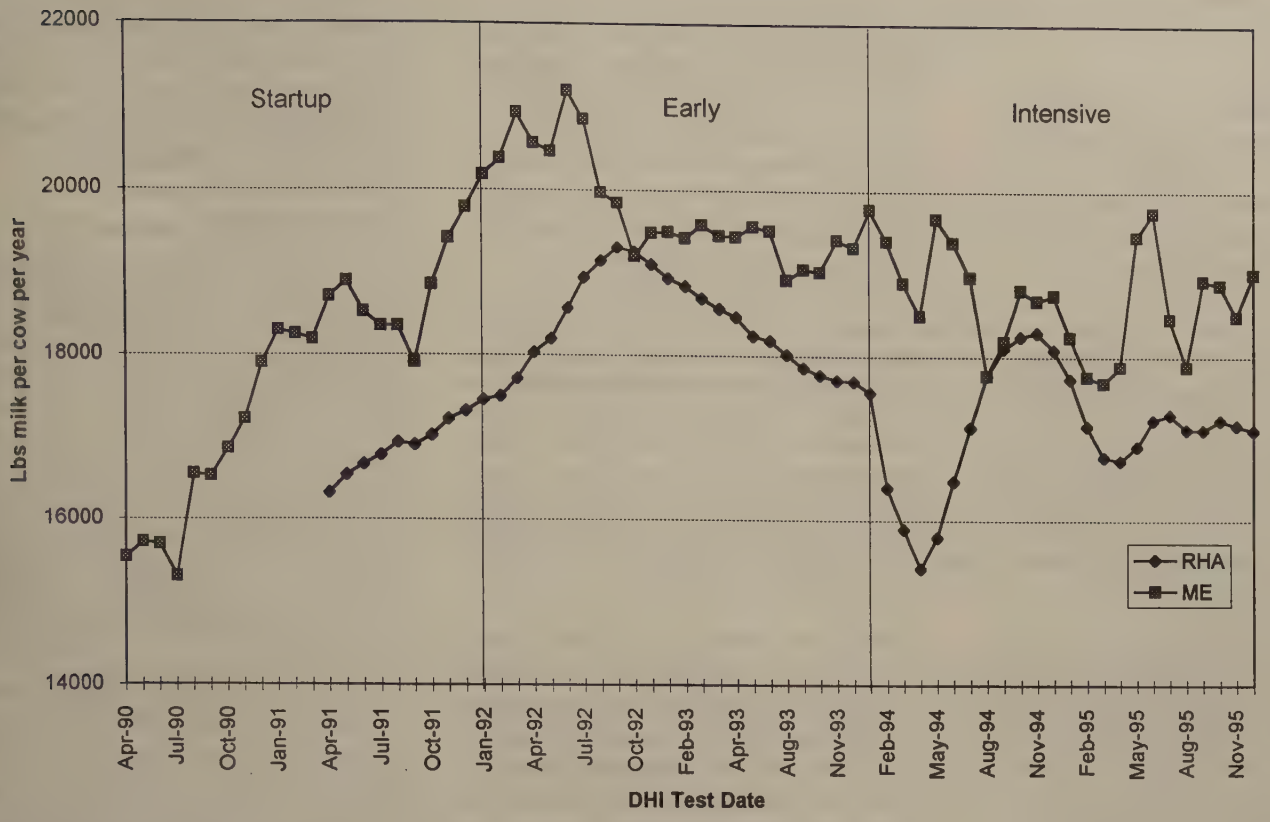

Figure 3. Milk Production Trends on the Kursenbaum Farm (1990-1995)

from various sources each year, a practice that increases the risk of introducing contagious mastitis pathogens to the herd, the Krusenbaums maintained a low average SCC.

Herd reproduction and genetics

The Krusenbaums rely exclusively on artificial insemination (AI), and reproductive performance of the herd has been good throughout the three phases. The average interval from calving to conception, called average days open, has improved by almost two weeks with the switch to seasonal calving and intensive grazing (Table 2, row 14). This positive trend is due to increased ease in heat detection. This is critical in AI, where the dairy manager must identify the cows to be bred.

Seasonal calving and intensive grazing improve estrus detection in two ways. First, heat exhibition is enhanced if there are two or more cows in estrus on the same day (Helmer and Britt, 1985). Because the entire herd has its calves and gets rebred in a short period, the larger population of sexually active cows increases the likelihood of having several animals in heat on any given day. Second, cows exhibit behavioral signs of estrus more frequently on an earthen surface than on concrete or other hard surfaces where footing is less secure (Britt et al., 1986). Before the intensive phase, efforts were made to detect estrus on cows year-round. In the winter, cows were confined to stalls for most of the day and turned outside onto a frozen concrete surface daily for exercise and heat detection. With the switch to seasonal calving, all heat detection efforts were conducted with cows on unfrozen, earthen surfaces.

Criteria for semen selection has changed slightly across the three phases. In very general terms, the wide choice of sires available in AI allows dairy farmers to emphasize production traits, body conformation traits, or both. An index called Predicted Transmitting Ability of Milk, Fat, and Protein $ (PTA$) is used to compare AI bulls by the productivity of their daughters. The Dairy Herd Improvement Association (DHIA) record system monitors the PTA$ value of the sires used in the herd and computes benchmark averages of the highest producing herds in the system. By the end of the start-up phase, AI sires used in the Krusenbaum herd averaged 188 PTA$, 24 PTA$ less than the sires used in all Wisconsin herds with RHA above 23,000 lb. After genetic counseling in the early phase, the sires used in the Krusenbaum herd exceeded the value of the highest production herds by 11$. However, sire selection criteria changed in the intensive phase to emphasize body conformation traits, and the PTA$ lagged the highest producing herds by 43$ (Table 2, row 15). Many graziers believe that emphasizing body conformation traits will result in offspring that perform better as grazing animals, but there is no scientific evidence to support that belief. The interval between choosing the semen and production of milk from the resulting offspring is almost three years, so the influence of reducing selection pressure on

Table 3. Economic performance on the Krusenbaum farm.

Economic Variable Indicators	Start-up 1990-91	Early 1992-93	Intensive 1994-95	Benchmark 1994-95[1]
1. Number of cows	40	48	69	76
2. Total farm income ($ per cow)	2675	2775	2800	2750
3. Basic cost ($ per CWT EQ)	7.82	6.75	6.98	7.30
4. Interest payment ($ per cow)	187	140	73	206
5. Net Farm Income From Operations ($)[3]	21,504	38,026	54,202	NA[2]
6. NFIFO ($ per cow)	552	792	793	675
7. Net Farm Income ($)[4]	21,504	38,026	81,100	NA[2]

[1] Agricultural Accounting and Information Management System (AAIMS), mean results from 904 dairy farms in 1994 and 934 dairy farms in 1995 (Frank, 1995b; Frank and Vanderlin 1996).

[2] It was not deemed useful to compare the Krusenbaum farm to the AAIMS survey data for economic variables dependent on farm size.

[3] Net Farm Income From Operations (NFIFO) is the return to the operator and family's unpaid labor and management plus the return to their equity capital.

[4] Net Farm Income is NFIFO plus one-time capital sales. This occurred in 1994, when cows that did not fit the seasonal calving window were sold at auction, and again in 1995 when tillage and other equipment of no use in an intensive grazing system was sold.

productivity seems distant. Nevertheless, the production difference is real and will be realized in coming years.

Economic Performance

As with any business, success must be also measured in economic terms. Table 3 summarizes several whole-farm economic indicators, shows how they have changed over time, and provides industry benchmark comparisons, primarily from the AAIMS survey results from 1994 and 1995 (Frank, 1995b; Frank and Vanderlin, 1996). Total farm income per cow (Table 3, row 2) has remained nearly constant on the farm over the six-year period, and is similar to the 1994 and 1995 benchmark income from the AAIMS sample. During this period, however, the number of cows has nearly doubled. While the income is primarily from milk production (Table 2, row 1), milk sales were augmented with crop sales in the early phase (Table 1, row 6) and with cull cow sales during the intensive phase (Table 2, row 11).

A strength in the Krusenbaum system is its low costs for inputs, labor, and interest. Input cost per hundredweight equivalent (CWT EQ) is below that of other farmers using the AAIMS program (Table 3, row 3). Basic cost per CWT EQ measures the input costs that farmers incur in generating total farm income, by converting all their income streams (milk, cull animals, custom work, and crop sales) to milk equivalents. However, this measure does not include cash expenses associated with paid labor or debt servicing. In fact, labor and interest payments add greatly to the cost of production on many farms. On the Krusenbaum farm, however, there have been no cash labor expenses to nonfamily members, and interest payments also are very low compared with the AAIMS sample, where the average is just over $200 per cow (Table 3, row 4). By leasing rather than owning the farm and by borrowing wisely, the Krusenbaums have kept interest payments down.

The third group of economic variables reflects the income available to the farm family. Net Farm Income From Operations (NFIFO, Table 3, row 5) is strictly the return to family labor, management, and equity capital. The Krusenbaum farm has had a positive and growing NFIFO in all six years, except for the dip in 1991 because of the low milk price. On a per cow basis (Table 3, row 6), the farm is doing a good deal better than the average farm in the AAIMS survey. Net Farm Income (Table 3, row 7) reached a high in 1994 of $95,042, and a two-year average of $81,100. Some of this increase came from the Krusenbaums having converted the equity in surplus dairy cows into cash in 1994 and selling some machinery. Seeing income increase like this was an extremely encouraging sign for the Krusenbaums, and meant they could rapidly pay down debt, increase personal consumption, and make new investments. The NFIFO and Net Farm Income indicate that this farm is a financial success.

Conclusions

It is clear from all indicators that the Krusenbaum farm can be considered a successful start-up. The pasture is supplying much of the herd's energy and protein needs (low purchased feed costs); it does not require major agricultural chemical purchases; nutrient inputs and outputs are nearly in equilibrium; and soil erosion is low. The farm also is poised to take advantage of the developing organic market in the region, as the production fields have received no commercial fertilizer for the past six years.

Herd performance also has been strong. The milk production level of 17,000 to 18,000 lb per cow places the herd in the upper third of all dairy herds in the state. Production per cow has declined about 7% with the switch from conventional stored feeds to seasonal calving and intensive grazing. The health of the herd has improved, as shown by reduced involuntary culling rates, somatic cell counts, and days open.

Economic performance has been the most surprising. In just six years, even without organic premiums, the farm has started to generate enough income that family income is competitive with other employment opportunities.

The Krusenbaums were successful for the following major reasons:

- **They set goals jointly and revisited them frequently.** Setting goals is not a static one-time task, nor is it something that only one person in the family can do. Both Altfrid and Sue were committed to developing a biodynamic dairy and it was that joint decision that made it possible to weather the drop in prices and income during the second year (1991).
- **They were quick to perceive problems and to respond to them.** The rapid evolution of the Krusenbaum operation demonstrates their unusual willingness to admit mistakes and try

alternatives. However, the speed with which they changed course sometimes had its drawbacks. For example, they made large investments in row crop machinery, a manure management system, and improvements in their stanchion barn—all of which were rendered useless when they decided to put their whole farm into management intensive grazing. Other decisions, such as increasing the herd size (twice) and experimenting with grazing, turned out to be cornerstones of their eventual success. It may be partly luck that none of their mistakes was fatal and none of their many changes cost them more than they could afford to lose. Their excellent record keeping and their willingness to try new alternatives and take risks were not luck, however. These characteristics enabled them to respond to problems and to be bold in designing solutions.

- **They gained experience and information from multiple sources.** They worked for and with other farmers to gain experience. Both attended meetings, joined a graziers network, and asked Extension for guidance in testing ideas. When they were considering grazing, they experimented with a small area, and only by the third year were they committed to putting the entire farm into pasture.
- **They rented some major assets.** Starting farmers usually cannot afford to own all the assets required to farm. Land is the best example. The return to land is comparable to returns to other assets, but much of the return is appreciation in value, a noncash income. Land ownership is a form of forced savings, and this can cause cash flow problems for beginning farmers. The Krusenbaums chose to lease their land, avoiding some of the debt burden that hampers many beginning farmers.
- **They kept excellent records.** Detailed financial records and analysis helped the Krusenbaums stay abreast of their financial situation, identify problems, troubleshoot, and evaluate alternatives. Forage sampling and DHIA records were important in developing and seasonally adjusting the feeding program. Field-by-field soil tests and crop yield estimates were important in establishing a manure management program.
- **They borrowed wisely.** Money is an asset. The interest paid on money is its rent. The Krusenbaums compared interest rates and refinanced and restructured their debt when the opportunities arose.

Several studies have shown that organic farming is a viable farming strategy, even without price premiums (Lockeretz et al., 1981; National Research Council, 1989; Reganold et al., 1993). This study has chronicled a successful start-up operation that is positioned to begin selling certified organic milk once a market develops. The farm family's conscious focus on quality of life, land stewardship, nutrient cycling, and herd health was the basis for rather than an impediment to developing a successful system.

Postscript

The influx of nearly $30,000 in 1994 and again in 1995 through the sale of dairy cows and machinery (Table 3, row 7) made it possible for the Krusenbaums to consider modifying their system again. In their search for an improved quality of life they built a New Zealand-style milk parlor to reduce the time spent in the barn milking. To pay for the installation, they expanded the herd. The increased level of debt and larger herd are again testing the financial and environmental sustainability of the farm. The resource base is more heavily exploited, and management skills are at a premium, especially now as the entire industry faces a more volatile milk market. In a sequel to this report, we will document how the farm weathers this expansion phase (1996-1998).

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Feedlot manure nutrient loadings on South Dakota farmland

Donald C. Taylor and Diane H. Rickerl

Abstract. *A key determinant of whether livestock manure is an asset or liability for agricultural producers and for society more generally is the amount produced relative to the nearby farmland area to which it can be economically transported for application. The objectives of this study are to estimate manure N and P loadings on the cropland and rangeland associated with 78 feedlot farm operations in South Dakota and to determine if they are greater for larger feedlots.*

A substantial fraction of the feedlot operators studied apply plant-available N and P in livestock manure at rates that exceed crop and grass fertility requirements, and intensity of manure nutrient loadings on cropland is strongly and positively related to feedlot size. These findings raise a warning regarding possible nonpoint-source pollution of vulnerable water resources from manure produced by fed cattle in larger feedlots.

Key words: fed cattle, feedlots, manure production, manure disposition

Introduction

Attitudes in the U.S. toward livestock manure have changed greatly over the past several decades. In the first half of the 20th century, manure was considered a significant resource in agricultural production. However, as a result of changes in technologies, institutions, and price relationships during the past four to five decades, manure has commonly come to be viewed as a waste product (Wadman et al., 1987; Kaffka, 1992; National Research Council, 1993). Nevertheless, in recent years some producers are again viewing manure as a resource with positive agronomic and economic value (Nelson and Shapiro, 1989; Honeyman, 1991).

Whether livestock manure is an asset or liability for agricultural producers and for society as a whole depends on the amount produced relative to the nearby farmland area to which it can be economically transported for application, and the soundness of management practices for handling, storing, and applying it (taking into account possible risks of soil and water contamination). In this article, which is focused on the first issue, we examine the production and disposition of livestock manure produced on 78 feedlot farming operations in South Dakota.

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Problem Identification

Benefits of manure

Livestock manure contains N, P, and K, which can substitute for these nutrients in synthetic fertilizer and, when managed efficiently, result in crop yields equivalent to those from similar amounts of nutrients in commercial fertilizers. In addition to the N, P, and K present in both livestock manure and synthetic fertilizer, livestock manure contains certain other macroelements (e.g., Ca) and microelements (e.g., B, Co, Cu, Mn, Mo, Zn) that can meet important nutrient needs of crops (Holt and Zentner, 1985; Walter et al., 1987; Office of Technology Assessment, 1990; Chase et al., 1991; National Research Council, 1993; Roka et al., 1993).

Furthermore, applying manure to farmland builds up soil organic matter. Accompanying this and associated processes are several benefits: improvements in soil tilth, aeration, biological diversity and activity, water infiltration, water holding capacity, and solar heat absorption capacity; greater soil moisture retention and less water runoff, with an associated reduction in leaching of nutrients into ground and surface water supplies; improvement in the aggregate stability of soils, which enhances the soil's resistance to water and wind erosion, compaction, and crusting; and improved chemical properties of soil, such as a greater cation exchange capacity, which increases the availability of micronutrients and buffers soil pH against rapid changes (Wallingford et al., 1975; Mathers and Stewart, 1984; Hornick and Parr, 1987; Baker et al., 1990; Koepf, 1993; National Research Council, 1993; Roka et al., 1993).

Possible limitations of manure

The National Research Council (1993), in its recent study *Soil and Water Quality, An Agenda for Agriculture*, reports that the increasing regional concentration of livestock in the U.S. and the increasing concentration of cattle in large confinement feeding operations cause more manure to be produced than can be used efficiently on nearby croplands. Baker et al. (1990), Logan (1990), Sutton (1994), and

Vanderholm (1994) note the potential adverse impacts of highly concentrated livestock on soil and water quality.

With concentrated livestock production, environmental problems can arise in connection with waste runoff or leaching from feedlots (hereafter referred to as "point-source pollution"), and nutrients leaching into soil and water from manure in excess of the nutrients required by crops (hereafter referred to as "nonpoint-source pollution"). Other things being equal, possibilities for pollution are greater with larger feedlots. (One factor that may not be the same, however, is the quality of livestock manure management. Raising 20,000 cattle in one well-designed, well-managed feedlot can cause less pollution than those same 20,000 cattle in 50 poorly designed and managed feedlots with 400 cattle each.) Point-source pollution may increase because of large amounts of feedlot waste available to run off into surface water or leach to groundwater near large feedlots. Nonpoint-source pollution may increase because economic disincentives for transporting manure long distances from its point of origin may result in excessively heavy manure applications on farmland close to large feedlots (Freeze and Sommerfeldt, 1985; Roka et al., 1993).

Point-source pollution includes runoff from feedlots to surface water and leaching to groundwater. Such runoff may contain high concentrations of nutrients (e.g., P), salts, pathogens, and oxygen-demanding organic material. When feedlot runoff enters streams or lakes, the excess organic material and nutrients can cause eutrophication, algal blooms, and oxygen depletion, which can kill fish (Paine, 1973; National Research Council, 1989, 1993; Logan, 1990). In South Dakota, 98% of lakes smaller than 5,000 acres do not meet fishable and swimmable standards. The lakes are severely harmed by nutrients from agriculture (South Dakota Dept. of Environment and Natural Resources, 1990).

When nutrients in animal manure applied to farmland exceed the requirements of crops, excess nutrients (especially nitrate-N) often leach through the soil and may reach groundwater. Groundwater exceeding 10 ppm nitrate-N is unsuitable for drinking purposes. The 1989 South Dakota Centennial Environmental Protection Act requires sampling of all new domestic wells in the state. Of the 747 wells sampled, 237 (32%) failed to meet the criterion of 10 ppm nitrate-N for safe drinking water (South Dakota Association of Conservation Districts, 1991).

Plant growth can be retarded by excessive manure applications to farmland because of the following possible chain of events: build-up of salts (e.g., NaCl) in soil; breakdown of soil structure, and reduced soil aeration and water infiltration. Ammonia may build up, which can damage emerging seedlings. When manure or plant residues are added to land, oxygen levels can drop and CO_2 levels can increase drastically, thereby inhibiting plant growth. Because heavy equipment often is involved in manure distribution, soil compaction can be accentuated by heavy manuring of fields (Mathers and Stewart, 1984; Midwest Plan Service, 1985; Kaffka, 1992; National Research Council, 1993).

Manure nutrient loading evaluation criteria

Identifying benchmarks against which manure nutrient loadings can be evaluated is difficult. Maximum "environmentally safe" nutrient loadings on farmland depend, among many factors, on site-specific soil N and P levels, soil properties and condition, aquifer depth, distance from surface water, crop nutrient requirements, conservation practices, and weather at the time of application. Nevertheless, because of the increased concentration of fed cattle and increased public concern over possible associated environmental pollution, regulatory authorities in several states now stipulate guidelines on maximum recommended levels of manure N for land application. In South Dakota, for example, agricultural waste plans that cover waste storage and utilization must be developed for new feedlots with a capacity of over 1,000 head and for any existing feedlot that has been shown to be the source of water pollution (Johnson and Ullery, 1993). The waste utilization plan requires annual soil tests, with subsequent manure applications not to exceed crop N requirements. Depending on the distance to surface water and the potential for soil erosion, the crop's P requirements may also need to be included in waste utilization plans.

Since corn and wheat are the main crops grown near South Dakota's feedlots, benchmark N and P levels against which manure N and P loadings were evaluated in this study are with respect to recommended N and P levels for corn and wheat on cropland and for grass on rangeland. Recommended fertilization levels for these crops are based on equations in Gerwing and Gelderman (1996). For example, equations for corn grain are as follows:

> Recommended N: 1.2 x (YG) - STN, where YG = yield goal in bu/A and STN = soil test N at 2-feet depth, in lb/A.
>
> "Bray-1 P recommendation": [(0.77-0.035 × STP) x YG] × 0.44, where STP = soil test P, in ppm.

These levels for cropland were evaluated using yield goals equal to historical county averages for corn and wheat (Ranek and Noyes, 1995) and average cropland soil test residual N and P levels (unpublished data, South Dakota State University Soil Testing Laboratory, April 1996) in the corresponding counties for the 78 feedlots studied. The following illustrative recommended levels for N and P are with respect to state-wide 5-year average yields of 81 bu/A for corn and 31 bu/A for wheat (Ranek and Noyes, 1995), and state-wide cropland average STN and STP values of 40 lb/A and 16 ppm, respectively (Ron Gelderman, South Dakota State University Soil Testing Laboratory, private communication, April 1996):

> for corn: N = 57 lb/A, P = 5 lb/A
>
> for wheat: N = 38 lb/A P = 3 lb/A

Since systematically collected South Dakota county-level data are not available on average rangeland yields and average rangeland soil test residual N and P, the evaluation of N and P loadings on rangeland in this study was done only at the state level, rather than the county level, as with cropland. With an assumed average grass yield of 1.2 ton/A (judgment of South Dakota Resource and Conservation Service personnel) and assumed zero residual N and P for rangeland (Ron Gelderman, South Dakota State University Soil

Testing Laboratory, private communication, April 1996), the benchmark levels for rangeland grass were determined to be 30 lb/A for N and 5 lb/A for P.

Concentration of fed cattle

Cattle feeding in South Dakota is less concentrated than in the four leading cattle-feeding states (Texas, Nebraska, Kansas, and Colorado). An average of only 15 cattle and calves are on feed per 1,000 A of cropland, and the average number of cattle marketed annually per feedlot is 121. The four leading cattle-producing states have from 3.3 to 5.6 times as many cattle and calves on feed per 1,000 A, and on average market from 7 to 68 times as many cattle per feedlot (U.S. Dept. of Agriculture, 1989; U.S. Dept. Of Commerce, 1989; Livestock Marketing Information Center, 1994).

Study objectives

The objectives of this study were to estimate levels of manure nutrient (N and P) loadings on the cropland and rangeland associated with 78 feedlot farm operations in South Dakota, and to explore the relationship between feedlot size and manure N loadings on cropland.

Materials and Methods

Cattle feedlots studied

The main data source in this study are the responses by 78 South Dakota cattle feeders to questionnaires mailed during winter 1991-92 to all cattle feeders in the state with a feedlot capacity of 500 head or more and to a random sample of approximately 12% of feedlots with less than 500 head (Taylor and Feuz, 1994). The mean design capacity of feedlots operated is 890 head, which is 10 to 15 times the statewide average (based on a state average of 121 fed cattle marketed per feedlot in 1993 and an assumption that an average of 1.5 to 2.0 batches of cattle are fed in each feedlot per year). An average feedlot manager in the study operates 1,475 A of cropland, which is 1.9 times the average (775 A) for all farmers in the state (U.S. Dept. of Commerce, 1994).

In addition to fed cattle, 51 (65%) of the 78 feedlot operators have other livestock and poultry enterprises. Of these, 26 have one other livestock enterprise, 14 have two, 9 have three, and 2 have four. The most common other livestock enterprise involves beef cows: 45 (58%) of the 78 cattle feeders maintain beef cow herds ranging from 11 to 550 head and averaging 135 head. Other livestock enterprises are as follows:

- Slaughter hogs: 15 operators selling an average of 750 head per year
- Brood sows: 11 operators with an average of 75 sows
- Dairy: 9 operators with an average of 90 cows
- Stocker cattle: 8 operators selling an average of 120 stockers per year
- Sheep: 3 operators with an average of 210 ewes
- Slaughter lambs: 3 operators selling an average of 135 lambs per year
- Broilers: 2 operators selling an average of 4,250 broilers per year
- Layers: 2 operators with an average of 270 hens.

In estimating the amount of manure produced on the 78 feedlot operations, attention was given to the manure produced both by fed cattle and by the animals in these other enterprises.

Estimated manure production

Since most of the surveyed feedlot operators apply manure in solid raw form, we assumed all spread manure to be solid raw. Estimating the amounts of livestock manure N and P available for crops and rangeland involved taking joint account of the following:

- Amounts of solid manure ('spreader weight') produced by different categories and weights of livestock and available for application to farmland
- Proportions of available manure assumed to be scraped, collected, and spread on cropland versus dropped on rangeland
- N and P nutrient content of manure produced by various species of livestock
- Fractions of total N and P present in manure assumed to be available for plant use.

Estimated values for these parameters were based on various findings reported in the literature, as follows.

Amounts of manure available for application to farmland. Estimated rates of livestock manure voided were based on Van Dyne and Gilbertson (1978), Killorn (1985), Midwest Plan Service (1985), Sutton et al. (1985), Ensminger (1987), Nelson and Shapiro (1989), Watts (1991), and Conservation Technology Information Center (1992). Amounts of manure produced by different types of beef cattle and sheep were reported to be directly proportional to body weight within each species and category. For hogs and poultry, on the other hand, reported rates of manure production differed for breeding versus finishing animals. Rates of manure production for different categories of hogs and poultry were based directly on per-day amounts reported in the literature, rather than calculated relative to species' baseline body weights (Table 1).

Based on Killorn (1985), Midwest Plan Service (1985), Sutton et al. (1985), Ensminger (1987), Nelson and Shapiro (1989), and Watts (1991), we used the following estimates of the dry matter content of manure produced by various species at the time of application to farmland: poultry, 55%; beef cattle and sheep, 30%; hogs and dairy cattle, 18%. Manure storage and handling losses were taken to be 11% (Van Dyne and Gilbertson, 1978). Table 1 shows the amounts of "spreader weight" manure computed from the amounts voided, adjusted for moisture content and storage and handling losses. (While manure dropping on grazing land is not literally in "spreader weight" form, an accurate portrayal of its N and P content is not violated when it is treated analytically as if it were.)

Proportions of manure spread on cropland versus dropped on grazing land. We assumed that manure dropped in drylot would be scraped, collected, and spread only on cropland. For fed cattle, total estimated manure produced was allocated to cropland versus rangeland according to the numbers of days fed cattle were respectively in drylot versus grazing on rangeland and crop residues, as reported by individual feedlot operators. For other categories of livestock and poultry, the following percentages of total manure

Table 1. Estimated amounts of "spreader weight" manure available for land application from various species and types of livestock and poultry.

Category of Livestock	Baseline Body Weight (lb)	Days in Herd or Flock	Available Manure	
			Per Day (lb)	Total (tons)
Beef cattle				
Service bulls	1,700	365	94	17.16
Brood cows	1,100	365	61	11.13
Replacement heifers	685	442	38	8.40
Finishing cattle	775	270[1]	43	5.81
Stockers	615	200	34	3.40
Backgrounded cattle	520	91	29	1.32
Dairy cows	1,300	365	93	16.97
Hogs				
Brood sows	350	365	11	2.01
Market hogs	135	150	11	0.83
Sheep				
Ewes	180	365	6.3	1.15
Market lambs	70	140	2.5	0.18
Poultry				
Layers	7	365	0.30	0.055
Broilers	7	45	0.40	0.009

[1] For illustration only.

available for application to farmland were assumed to be spread on cropland versus dropped on rangeland, taking into account data reported by the Office of Technology Assessment (1990):

- Beef brood cows, service bulls, and stockers: 20%-80%
- Dairy cows: 50%-50%
- Brood sows, market hogs, market lambs, and poultry: 100%-0.

N and P nutrient content of livestock manure. Data on estimated percentages of N and P in the manure produced by various species of livestock were obtained from Cooke (1982), Killorn (1985), Midwest Plan Service (1985), Sutton et al. (1985), Ensminger (1987), Schmitt (1988), Baker and Raun (1989), McGary (1989), Nelson and Shapiro (1989), Watts (1991), and Gerwing and Gelderman (1996). The assumed N and P percentages ("spreader-weight," not oven-dried weight) of manure produced by various species are shown in Table 2.

Percentages of plant-available N and P in manure. Of the total manure N and P estimated to be produced and applied annually to farmland, 75% of N and 100% of P were assumed to be available over time for plant use. These assumptions were based on Lorimor et al. (1995) and research at Pennsylvania State University reported by McGary (1989).

Table 2. Assumed N and P content in "spreader weight" manure from various livestock species (%).

	N	P
Poultry	1.74	0.70
Sheep	0.99	0.20
Beef cattle	0.72	0.23
Dairy cattle	0.49	0.10
Hogs	0.42	0.14

Estimated annual manure N and P per acre. Estimated average amounts of manure N and P per acre (i.e., manure N and P fertilizer credits) available for use by crops and grasses each year on each feedlot operator's farmland were determined by the following process:

1. Multiplying the N and P percentages for each type of livestock in Table 2 by the corresponding per-head amount of manure in Table 1 and the number of that type of livestock for the operator.
2. Multiplying the resulting total N by 0.75.
3. Apportioning total manure N and P produced on each farm between cropland and rangeland.
4. Dividing these amounts by the areas of cropland and rangeland on the farm, respectively.

Thus, assumptions for the following items were common for all 78 feedlots: "spreader weight" daily manure production rates per 100 lb of liveweight for beef cattle and sheep, and per head for various types of hogs and poultry; proportions of manure spread on cropland versus dropped on rangeland (except for fed cattle); manure N and P nutrient content; and percentages of applied N and P available to crops and grasses. We also assumed that the operators followed sound management practices in handling, storing, applying, and incorporating manure. Furthermore, manure was assumed to be applied uniformly over cropland and dropped uniformly over rangeland. We acknowledge that these assumptions are not totally realistic, but resources did not permit us to gather farmer-specific information on these variables. Results of the study must therefore be considered as indicative rather than definitive.

Results

Total manure produced and applied

An estimated average of 5,370 tons of manure is produced annually for each feedlot studied, of which 77% is spread on cropland and 23% on rangeland. Finishing cattle account for 92% of total manure produced, beef cow and hog enterprises each for 3%, dairy for 2%, and sheep and poultry for 0.1%.

Estimated annual applications of livestock manure on cropland range among feedlots from 0.4 to 28 ton/A, with an average of 6.1 ton/A. Nineteen percent of feedlot operators spread more than 10 ton/A on their cropland and 4% spread more than 20 ton/A.

Cropland loading rates

The estimated annual N loading on cropland from livestock manure ranges

Table 3. Frequency distribution of plant-available N and P from livestock manure spread on cropland, 78 feedlots.

N		P	
App. Rate (lb/A)	%	App. Rate (lb/A)	%
>250	5	>70	10
100 - 250	19	45 - 70	13
57 - 100	18	30 - 45	10
38 - 57	17	20 - 30	13
25 - 38	12	10 - 20	26
15 - 25	14	5 - 10	14
<15	15	3 - 5	9
		<3	5
Range (lb/A)	5 - 380		2 - 159
Mean (lb/A)	73.2		30.5

among feedlot operations from 5 to 380 lb/A, with an average of 73 lb/A (Table 3). For 5% of producers, manure provides N at more than 250 lb/A, for 24% more than 100 lb/A, for 42% more than 57 lb/A, and for 59% more than 38 lb/A. At the other extreme, manure for 15% of producers provides N at less than 15 lb/A.

The estimated annual P loading on cropland ranges from 2 to 159 lb/A, with an average of 31 lb/A. Manure for 33% of producers provides P at more than 30 lb/A, for 72% more than 10 lb/A, for 86% more than 5 lb/A, and for 95% more than 3 lb/A.

Rangeland loading rates

The estimated annual N loading on rangeland from livestock manure ranges from 0 to 88 lb/A, with an average of 25 lb/A (Table 4). For 36% of producers, manure provides N at more than 30 lb/A, and for 63% more than 10 lb/A. At the other extreme, 32% of producers have no livestock that graze (and hence drop manure) on rangeland.

The estimated annual P loading on rangeland ranges from 0 to 36 lb/A with an average of 10 lb/A. For 32% of producers, manure provides P at more than 15 lb/A, for 46% more than 10 lb/A, and for 60% more than 5 lb/A.

Are cropland manure nutrient loadings larger for larger feedlots?

Estimated plant-available N from livestock manure spread on cropland is directly related to feedlot size (Fig. 1). Manure N loadings exceed 100 lb/A for only 16% of feedlots having a design capacity of 1,000 head or less. In contrast, this level is exceeded by 33% of feedlots with a design capacity of 1,001-2,000 head and 75% of feedlots with more than 2,000 head. Thus, as feedlots become larger, there is a clear pattern of the number of cattle increasing faster than the amount of cropland.

Table 4. Frequency distribution of plant-available N and P from livestock manure spread on rangeland, 78 feedlots.

N		P	
App. Rate (lb/A)	%	App. Rate (lb/A)	%
>50	14	>20	16
40 - 50	13	15 - 20	16
30 - 40	9	10 - 15	14
20 - 30	16	5 - 10	16
10 - 20	11	> - 0-5	8
>0 - 10	5	0	32
0	32		
Range (lb/A)	0 - 88		0 - 36
Mean (lb/A)	24.9		10.1

Comparison with benchmark application rates

Of the feedlot operators studied, 42% exceed the illustrative average state-wide benchmark level of 57 lb/A for N on corn, and 59% exceed the 38 lb/A benchmark level for N on wheat (Table 5). Because many location-specific factors—including local crop yields, weather, and soil residual nitrate levels—are important in determining crop utilization of manure N, it is conceptually sounder to evaluate the status of manure N on a finer level. Compared with respective county benchmark levels for corn and wheat, manure N loadings are greater for 41% and 51%, respectively, of the feedlot operators studied. For manure P, county benchmark levels for corn are exceeded by 52% of feedlot operators and for wheat by 71%. For rangeland grass production, the average state-wide benchmark level for manure N is exceeded by 37% of feedlot operators and for manure P by 60%.

Thus, many of the feedlot operators studied apply plant-available N and P at rates that exceed crop and grass fertility requirements, especially for P. The latter finding is consistent with Klausner (1989) and National Research Council (1993), who state that levels of manure just adequate to meet a crop's N need often are excessive for P.

Summary and Conclusions

This study shows that South Dakota feedlot operators often apply manure beyond crop and grass fertility requirements, especially for larger feedlots. These findings are a warning regarding possible nonpoint-source pollution of vulnerable water resources.

However, the warning is not clear. While we tried to gather and interpret carefully the data reported in the literature and secure additional primary data, some of the data are acknowledged to be "soft." Furthermore, the findings are not representative of the total population of feedlots in South Dakota, since the average feedlot studied is 10 to 15 times greater than the state average.

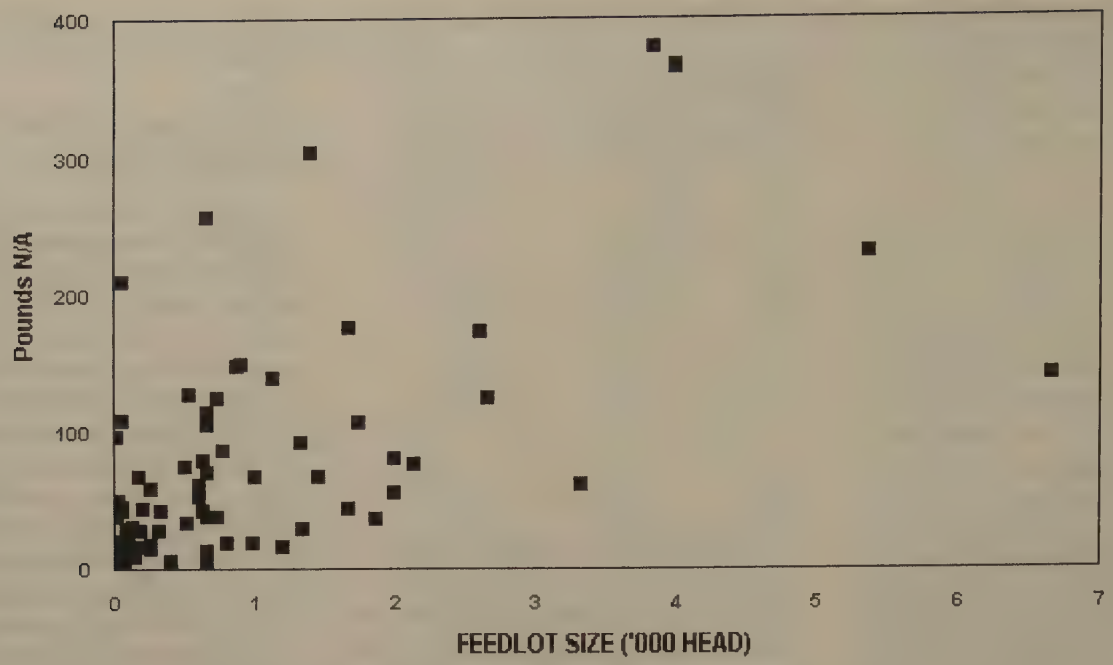

Figure 1. Plant-available N from livestock manure spread on cropland, by feedlot size.

Table 5. Instances in which N and P plant-need benchmark levels are exceeded, 78 feedlots.

	Instances with Evaluation Criterion Exceeded at Indicated Level (%)	
	State	County
Cropland		
N		
Corn grain	42	41
Wheat	59	51
P		
Corn grain	86	52
Wheat	95	71
Rangeland grass		
N	37	N/A
P	60	N/A

With this qualification, the study findings show a risk of nonpoint-source pollution problems from larger feedlots in areas with vulnerable surface and ground water. The potential problems are greater for P than N.

To improve the data base for more refined examination of the issues raised in this study, we suggest empirical research designed to estimate amounts and nutrient content of manure produced in feedlots representing various conditions, and to determine relationships among the following: manure production from feedlots of different sizes; cropland areas required for environmentally safe distribution of that manure; and distances that manure can economically be transported. Research also is needed to determine the vulnerability of particular sites to contamination of surface and ground water and to examine technical and economic possibilities of alternative systems for handling manure.

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INSTITUTE NEWS

Wallace Lecturer Sidey Recounts "The Greatest Story Never Told"

The ability of the American farmer to produce "an abundance of food the likes of which the world had never seen or imagined" is "the greatest story never told," according to Hugh Sidey, who presented the 1998 Henry A. Wallace Annual Lecture in March. Sidey, Contributing Editor of *Time* Magazine and author of its column, "The Presidency," was born in Adair County, Iowa, where Henry A. Wallace was born.

His lecture, entitled "The Greatest Story Never Told: The Food Miracle in America," referred to a current generation "in their 40's who have only vague ideas of where food comes from and how it gets to them....That great cultural foundation of plentiful food at prices that anyone can afford is as taken for granted in our time as the air we breathe."

Reviewing the era of Henry Wallace, Sidey referred to the "good things happening in the world" then that Wallace had put in motion. "Almost every week the family newspaper had stories about new terraces being built, tree shelters being planted, farm ponds dug," he said. "The electric lines stretched farther and farther into the county, and the 4-H clubs became a young army. When I fly across the country these days and I see the glint of thousands of farm ponds in the setting sun, when I glimpse the graceful designs of crops in contours and the enduring shelterbelts that march from Canada to the Gulf, I think that these are the fingerprints of Henry Wallace put down on our land over the last 65 years, a stunning legacy from an uncommon man." But today the population of Adair County is roughly half of what it was when Henry Wallace was born there, and the farms are twice or three times as large, Sidey said.

"We could use another Henry Wallace, or maybe many Henry Wallaces, and not necessarily those who experiment with new crops and have technical skills in growing and marketing food," Sidey said. "The time calls for men and women who understand this is a quietly crucial moment for our exuberant, well-fed nation. Decisions made now will as in Wallace's day echo through the next 65 years. Henry Wallace above all else understood the crisis of his time—spiritual as well as physical—and the need for bold action to use and preserve this greatest of all resources—our land and those people who tend it."

Wallace Institute Elects New Offices, Installs Johnson

The Wallace Institute Board of Directors has elected new officers for the coming year, re-elected three members, and installed one new member. The newly installed member is Paul Johnson, former Chief of the USDA's Natural Resources Conservation Service and now a farmer in Iowa. The new President is Cornelia Butler Flora, Director, North Central Region Center for Rural Development, Iowa State University; Vice President is Dr. Frederick Magdoff, Professor, Department of Plant and Soil Science, University of Vermont; Secretary is Christine (Cass) Peterson, owner/operator, Flickerville Mountain Farm and Groundhog Ranch; and Treasurer is Jose Montenegro, Director, Rural Development Center, Salinas, California.

Members re-elected for a second term were Dr. Frederick Kirschenmann, manager, Kirschenmann Family Farms; Frederick Magdoff; and James Stephenson, Executive Director, Pamlico-Tar River Foundation, North Carolina. The Board also conducted a major discussion of the findings of a report prepared by Robert Gray of Resource Management Consultants that is part of the Institute's long-range planning process currently underway.

Whole Farm Planning Report Surveys Nine Activities

Whole Farm Planning: A Survey of North American Experiments, a new report just released by the Wallace Institute, examines nine whole farm planning activities in the United States and Canada. The survey and analysis concluded that because whole farm planning has not attracted a uniform constituency, it cannot be a simple, straightforward exercise.

The report also identifies several areas for improvement in most of the whole farm planning programs surveyed. The full report is $10 from the Wallace Institute, 9200 Edmonston Road, #117, Greenbelt, MD 20770; (301) 441-8777; e-mail hawiaa@access.digex.net.

Organic vegetable production in the U.S.: Certified growers and their practices

Jorge Fernandez-Cornejo, Catherine Greene, Renata Penn, and Doris Newton

Abstract: *Organic farming systems differ fundamentally from conventional ones in their primary focus on management practices that promote and enhance ecological harmony. Organic farmers also tend to have a different socioeconomic profile. In this study, we summarize average socioeconomic characteristics and production practices of a national sample of about 300 certified organic vegetable growers from 14 states and compare them to a large sample of about 6,900 conventional vegetable growers. We also examine the specific materials used by organic growers for pest and nutrient management.*

Organic vegetable growers tend to be younger, more educated, less experienced in farming, and less likely to have grown up on a farm than conventional vegetable growers, and tend to operate smaller farms. Over three-quarters of the organic vegetable growers surveyed have small operations (less than 10 acres of vegetables), and they are much younger and work fewer days in off-farm jobs than conventional small growers. In contrast to conventional marketing practices, nearly half the surveyed organic growers, and the majority of small ones, market their vegetables directly to consumers through farmers' markets and other direct marketing channels.

The organic growers rely primarily on traditional organic processes such as green manuring (legumes), animal manuring, composting, and crop rotation to supply crop nutrients, and on cultural and biological tools, including pest-resistant plant varieties, water management techniques, adjustment of planting and harvesting dates, and beneficial organisms, for pest management. Animal meal, fish products, and lime are their most frequently reported supplemental nutrient sources (14, 20 and 28%, respectively, reported using these materials), and Pyrellin EC and petroleum-based soaps were the most frequently reported supplemental pest management materials (used by 6 and 8%, respectively). The pest and nutrient materials used by the organic growers are generally consistent with current guidelines of major certification organizations that provide services to organic growers, and there is high consistency among those guidelines and national recommendations for most of these materials.

Key words: organic farming, ecological production, vegetable crops, nutrient management, pest management

Consumer demand for organically produced food is driven by both environmental and food safety concerns (Goldman and Clancy, 1991; Bruhn et al., 1992; Weaver et al., 1992; Davies et al., 1995; Cuperus et al., 1996). Organic systems, which exclude the use of most synthetic chemicals, offer a way for farmers to reduce pesticide use in agriculture and to adopt ecologically sound production practices.

Although national data on organic production are incomplete, the available statistics indicate that organic farming is a small but fast-growing segment of the U.S. farm sector. The number of certified organic farmers—those who use organic farming systems and use a public or private certifying agency to verify their use of organic methods—grew to nearly 5,000 in 1995, up by over 70% from the 1991 figure (Dunn, 1996).

Specialty crop producers have been entering the organic market faster than in many other sectors. Close to 3,000 certified organic growers were producing fruit, nut, and vegetable crops on about 91,000 acres in 1994 (Dunn, 1995). Vegetable crops were grown on over half this land in 1994, and organic vegetables accounted for over 1% of total U.S. vegetable land.

Over half the states in the U.S. have laws or rules regulating the production and marketing of organically grown food and fiber. This organic legislation varies widely by state, but frequently covers production standards, transition periods, record keeping, labeling, and inspection requirements (Howell, 1989). The Organic Foods Production Act, passed as part of the Food, Agriculture, Conservation, and Trade Act of 1990, will require all but the smallest organic growers (those with annual sales less than $5,000) to be certified by a state or private agency accredited under national standards currently being developed.

This paper reports the results of an organic vegetable survey administered by

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the U.S. Department of Agriculture in 1994 as part of its ongoing effort to gather information on U.S. agriculture. The objectives of the paper are: to profile the socioeconomic characteristics and cropping practices of certified organic vegetable growers, based on the 1994 national survey of organic growers, and compare them with conventional producers; to highlight differences between large and small organic growers; and to describe the pest and nutrient materials that the organic growers reported using and compare them with the National Organic Standards Board (NOSB) recommendations made to the USDA in 1996 for the "National List" of materials to be approved or prohibited for use in organic crop production under the Organic Foods Production Act.

The National Survey Data

The data summarized in this study were obtained from a national sample survey of certified organic producers that was part of the 1994 USDA Agricultural Chemical Use Survey for vegetables. The vegetable survey was administered between October 1994 and February 1995 in fourteen major vegetable-producing states, and included twenty vegetable crops. This survey was part of USDA's ongoing Pesticide Data Program (PDP). PDP surveys are designed by USDA's Economic Research Service (ERS) and National Agricultural Statistics Service (NASS), and are administered by NASS. The survey includes three phases: phase I is a screening phase to determine which operators have specific vegetable crops, and the amount of land in each; phase II collects chemical use, cropping practices, and socioeconomic information; phase III is primarily economic, collecting information on costs and prices, but also some information on pest and nutrient management.

The sample population for phase I includes all growers of fresh or processed vegetables (including strawberries and melons) who have at least one acre of a vegetable crop and are on the NASS list frame. The list frame for the 1994 vegetable survey was supplemented with a partial list of certified organic growers available at the time of the survey (U.S. Dept. of Agriculture, 1995a). The sample population for phase II includes all growers who answered phase I and grow vegetable crops, plus nonrespondents or inaccessible operators. The phase III sample population was a subset of all operators who completed phase II.

The NASS list frame is a database of names and addresses of commercial growers, with control data. The list was originally compiled in 1975 and is updated annually, with about 66% of the records being changed yearly (U.S. Dept. of Agriculture, 1995b). Although the list contains a substantial coverage of small farms, NASS's standards for list completeness heavily favor large farms. The NASS list frame currently covers 58% of all U.S. farms and accounts for 82% of all land in farms (U.S. Dept. of Agriculture, 1995b.) However, only 40% of specialty farms (fruit, vegetable, and others) are covered, and coverage is skewed toward larger farms. The list frame covers almost 75% of specialty farms with gross annual sales over $100,000 and 50% of those with sales between $10,000 and $99,999, but only 26% of those with sales between $1,000 and $9,999 (U.S. Dept. of Agriculture, 1995b).

A stratified sampling technique was used to draw the sample. Each stratum is a mutually exclusive set of the commodities of interest. Farms are partitioned such that each farm is associated with only one stratum. The total number of vegetable farms included in phase II of the vegetable survey was 9,034, from which 6,916 completed responses were obtained. The vegetable survey included a special section that was completed by all the respondents who reported having "certified organically grown" crops. A total of 303 certified organic vegetable growers completed this special section. This number is about 20% of all certified organic growers of vegetables in 1994 (total estimated from Dunn, 1995). The organic survey included questions on nutrient management materials and practices (including manure, compost, composted manure, cover crops, rotational crops, and intercropping), pest management materials and practices (including purchase of beneficial organisms, provision of habitat for beneficials, and use of pest-resistant plant varieties), and the operator's socioeconomic characteristics.

The economic portion (phase III) of the vegetable survey also contained pest and nutrient management questions, and was completed by a subset of growers selected randomly from the phase II sample of vegetable growers. This subset included 727 conventional growers, from which 509 completed responses were obtained. While most of the averages reported for conventional growers have been based on the larger survey with 6,916 responses, some questions on nutrient and pest materials and practices were only asked on the economic portion; those results are based on this smaller number of responses. Also, the number of responses varies slightly because some growers did not answer particular questions.

Survey results

Most previous surveys of organic and other "alternative" producers have been regional (Baker and Smith, 1987; Anderson, 1990; Batte et al., 1993; Farm Aid News, 1995). The Organic Farming Research Foundation (1993,1996) recently completed several large nationwide surveys of organic growers, including vegetable growers, but specific results for organic vegetable growers were not reported. Some socioeconomic characteristics of organic vegetable growers in the 1994 vegetable survey, especially age, educational level, and farm experience, are consistent with previous findings for all organic farmers.

General characteristics

The vegetable survey indicates that most certified organic vegetable farms are small. More than 60% of the surveyed organic growers have less than 5 acres, while more than 60% of the conventional growers surveyed had more than 10 acres (Table 1). However, several major certification organizations are reporting increases in the average size of organic vegetable farms during the mid-1990s (Greene and Calvin, 1997). Also, large conventional farms may have been over-represented in the survey, since the vegetable survey sample was drawn from a list frame that targets large operations, as noted.

The top state in number of organic vegetable growers surveyed was California

Table 1. Distribution (%) of conventional and organic vegetable farms surveyed, by land in vegetables, 1994.

Land in vegetables (A[1])	Conventional			Organic		
	Small (<10 A)	Large (≥10 A)	All	Small (<10 A)	Large (≥10 A)	All
<1	20	0	8	33	0	26
1 - 4.9	47	0	18	49	0	37
5 - 9.9	33	0	9	18	0	13
10 - 49.9	0	38	27	0	50	12
>50	0	62	38	0	50	11
Total[2]	100	100	100	100	100	100
Average size (A)	3.6	494.9	111.8	2.7	240.8	54.6
Number responding	2581	4199	6780	237	66	303

[1] A = Acres.
[2] In all tables, columns may not add to 100% because of rounding.

(30%), followed by Oregon (16%), Texas (11%), New York (11%), and Michigan (8%) (Table 2). Other states in the survey were Arizona, Florida, Georgia, Illinois, New Jersey, North Carolina, Washington, Wisconsin, and Minnesota. Michigan, California, New Jersey, and North Carolina were the top states in number of conventional vegetable growers, followed by New York. The largest concentration of organic vegetable farms as a share of all vegetable farms surveyed in a given state occured in California and Oregon (Table 2); the lowest concentrations were in Minnesota, Florida, and Illinois. However, the 14 states included in the vegetable survey were the top states in total land in vegetables. The ranking by number of farms is different for conventional farming, and is also likely to be different for organic farming.

The crops most widely grown by the surveyed organic growers were tomatoes, sweet corn, lettuce, strawberries, onions, and carrots (Table 2). Among conventional growers, the largest proportion grew sweet corn, followed by melons. The largest concentration of organic growers as a share of all growers growing a given crop occured with lettuce, followed by broccoli and carrots. While the vegetable survey collected data on a total of twenty crops, the number per state varied substantially, ranging from two in Minnesota (processing sweet corn and green peas) to nineteen in California. Moreover, small organic producers may have been growing a larger set of Asian, Italian, and other specialty vegetable crops targeted to niche markets that are not captured in the survey.

Organic vegetable growers generally are younger (54% are 45 years old or less compared with 37% of the conventional growers) (Table 3) and have less farm experience (Table 4). They also are more educated (53% of the organic growers completed college vs. 23% of the conventional groups) (Table 5), and are less likely to have grown up on a farm (43% vs. 87%) (Table 6). There are no large overall differences in occupation between organic and conventional vegetable growers, but conventional growers are less likely to work off-farm (Tables 6 and 7).

Small farmers in the U.S. have been characterized as retired or semiretired, part-timers, and lifestyle farmers who are not dependent on farm income (Jackson, 1997). The small organic growers (those with less than 10 A, who make up three-quarters of the surveyed organic growers), do not fit that characterization. Only 17% of the small organic growers in the survey are over 55 years old, compared with nearly half the small conventional growers, and the proportion of small organic growers over 65 years old was one-fourth that of the conventional growers (Table 3). Furthermore, only 14% of the small organic growers work over 200 days a year off-farm, compared with 23% of the small conventional growers. Among organic growers, larger growers are younger and spend less time in off-farm work than the smaller ones (Tables 3 and 7).

Organic growers also differ from conventional growers in their sources of information for pest control (Table 8). The most important sources among organic growers are other growers and grower associations (30% together), while the main source for conventional growers is farm supply and chemical dealers (37%). In contrast to previous studies of organic farmers, which "consistently found that organic farmers are dissatisfied with traditional agricultural information sources" (Anderson, 1990), both conventional and organic growers use extension advisors and publications to a similar degree (more than 20%) (Table 8). Large organic growers relied mostly on extension advisors, but conventional and small organic growers consulted both advisors and publications, underscoring the need for extension to continue using multi-tactic communication methods. Over 20% of the organic growers, in comparison with a negligible number of conventional growers, reported that newsletters, trade magazines and demonstration projects were their most important sources of information. Only 1% of the organic growers used processors as their major source of pest control information, compared with 10% of the conventional growers. This partly reflects the smaller proportion of processing crops grown by organic growers, but also highlights the need for processors to gain expertise with organic farming systems.

Nearly half the surveyed organic vegetable growers marketed their certified organic produce directly to the consumer through farmers' markets, consumer supported agriculture arrangements, and other direct marketing channels (Table 9). Strikingly, it has been reported that few conventional produce growers (about 2%) sell directly to consumers (McGlaughlin and Pierson, 1983). Among organic growers,

Table 2. Distribution (%) of conventional and organic vegetable growers surveyed, by state and crop, 1994.

	Conventional			Organic		
	Small	Large	All	Small	Large	All
			Distribution by State (%)			
Arizona	*	1	1	2	*	2
California	6	13	10	20	67	30
Florida	4	7	6	2	**	2
Georgia	9	7	8	5	*	4
Illinois	4	6	5	1	*	1
Michigan	14	12	13	10	**	8
Minnesota	*	3	2	*	*	*
New Jersey	19	5	10	5	*	4
New York	9	9	9	13	5	11
North Carolina	16	6	10	3	**	3
Oregon	5	8	7	19	5	16
Texas	7	8	7	12	8	11
Washington	2	7	5	6	6	6
Wisconsin	4	10	8	2	5	3
Total	100	100	100	100	100	100
			Distribution by Crop (%)			
Asparagus	4	4	4	3	*	2
Broccoli	*	1	1	4	8	5
Carrots	*	2	2	7	5	7
Cabbage, FM	4	4	4	2	5	2
Cauliflower	*	*	*	1	**	2
Cucumber, FM and Pr	4	7	6	2	*	2
Lettuce	*	1	1	*	26	11
Melons (all)	10	12	11	5	8	6
Onions	4	8	7	8	**	7
Peas, green	*	6	4	*	**	1
Peppers, bell	4	2	3	*	*	1
Snap beans, FM	4	3	3	3	**	3
Snap beans, Pr	*	6	4	*	**	1
Sweet corn, FM	31	12	19	22	5	18
Sweet corn, Pr	*	15	9	*	8	2
Strawberries	17	5	10	10	**	8
Tomatoes, FM	14	3	7	24	11	21
Tomatoes, Pr	*	3	2	*	11	1
Other	3	3	3	*	**	1
Total	100	100	100	100	100	100
Number responding	2581	4199	6780	237	66	303

* Less than 1%.
** Less than 5% (three growers or fewer).
FM = Fresh market.
Pr = Processing.

far fewer large operations sold their crops directly to the consumer (only 12% of the large organic growers used direct marketing channels, compared with 60% of the small organic growers). Large organic growers preferred to sell their crops to grocery wholesalers or distributors (26%), to processors (17%), through brokers (21%), or to packer/shippers (14%).

The increasing number of organic vegetable growers who have become certified over the last decade has paralleled the strong growth in the number of public and private certification agencies during this period. Over 80% of the surveyed growers had become certified since 1986 (Table 10). The first certification agencies began appearing in the early 1970s, and only 3% of the vegetable growers began certifying their crops during that period.

Cultural and biological management

The focus of organic farming systems is on ecological harmony through recycling nutrients and maintaining ecological balances for soil and crop management; this fundamentally distinguishes them from conventional agriculture. The NOSB recommends, as a major goal for organic agriculture, replacing material inputs, both

Table 3. Age distribution (%) of conventional and organic vegetable growers surveyed, 1994.

Age (Years)	Conventional			Organic		
	Small	Large	All	Small	Large	All
20 - 35	7	12	10	11	8	10
36 - 45	20	30	27	40	55	44
46 - 55	24	26	25	32	27	31
56 - 65	24	21	22	11	6	10
>65	25	12	16	6	5	6
Total	100	100	100	100	100	100
Number responding	2000	4556	6556	236	66	302

Table 4. Distribution (%) of conventional and organic vegetable growers surveyed by years operating the farm, 1994.

Years operating the farm	Conventional			Organic		
	Small	Large	All	Small	Large	All
1 - 5	8	4	5	26	8	22
6 - 10	12	10	11	27	14	24
11 - 15	12	14	13	17	29	20
16 - 20	17	19	18	15	26	18
21 - 25	10	13	13	6	9	7
26 - 30	10	11	11	4	5	4
>30	31	20	30	5	9	4
Total	100	100	100	100	100	100
Number responding	2007	4557	6564	236	65	301

Table 5. Distribution (%) of conventional and organic vegetable growers surveyed, by operator's education, 1994.

Operator's Education	Conventional			Organic		
	Small	Large	All	Small	Large	All
Less than high school	18	10	13	4	3	3
Completed high school	38	39	39	14	17	15
Vocational training after high school	5	4	5	2	*	2
Some college	17	23	21	27	30	28
Completed college	15	21	19	33	36	34
Graduate school	6	3	4	20	14	19
Total	100	100	100	100	100	100
Number responding	2006	4554	6560	236	66	302

* Less than 1%.

synthetic and natural, with cultural, biological, and other management tools. The fundamental components and natural processes of ecosystems, such as soil communities, nutrient cycling, species distribution and competition, and succession in natural ecosystems, which are pivotal in the use of cultural and biological tools for pest and nutrient management, are reviewed by Thomas and Kevan (1993).

Biological pest management tools include the use of microbial organisms, such as *Bacillus thuringiensis* (Bt), habitat provision for pest predators and parasites and other beneficial organisms (sometimes categorized as a cultural management tool), purchase and release of beneficial organisms, and use of crop varieties bred for resistance to insects and disease. Cultural pest management methods work by preventing pest colonization of the crop, reducing pest populations, reducing crop injury, and enhancing the number of beneficials in the cropping system; they include crop rotation, tillage, appropriate choice of planting and harvesting dates, trap crops, and water management techniques. Biological and cultural tools for pest and nutrient management that do not require purchase of off-farm inputs include habitat management for beneficial organisms, appropriate choices of planting and harvesting dates, and the use of noncommercial manure.

Bt so far has had more commercial success among both conventional and organic growers than any other microbial organism used to control crop pests. It is used by 12% of the conventional growers and 13% of the organic growers surveyed (Table 11). It has been popular with organic growers because of its effectiveness and environmental safety. One reason for its popularity among conventional growers is its effectiveness against some insects that have become resistant to chemical pesticides.

Habitat provision for beneficials is an ecological approach to pest management that is popular with organic growers. Growers practice conservation of beneficial insects and other organisms by ensuring that their needs for alternative hosts, adult food resources, overwintering habitats, a constant food supply, and other ecological requirements are met. In 1994, 58% of the certified organic vegetable growers provided habitat for beneficials (Table 11).

Growers may also augment the population of beneficials through mass production and releases in the field, which can be timed for when the pest is most vulnerable, be made repeatedly, and be used when the natural enemy is not present or cannot respond quickly enough to the pest pressure. Beneficial organism releases were made by 5% of the conventional growers and 46% of the organic growers (Table 11). For many organic growers, the ultimate goal of these "augmentative" techniques may be to establish a permanent population of these beneficial organisms that keeps crop pests in balance.

Cultural tools also are used extensively in organic farming systems, and organic and conventional vegetable growers differ

Table 6. Distribution (%) of conventional and organic vegetable growers surveyed, by primary occupation of the operator and farm background, 1994.

Operator's primary occupation	Conventional			Organic		
	Small	Large	All	Small	Large	All
Farm operator	71	91	85	76	91	79
Hired farm manager	1	3	2	2	8	3
Non-farm work	29	6	13	23	**	18
Total	100	100	100	100	100	100
Did operator grow up on a farm?	82	90	87	38	62	43
Number responding	2011	4576	6587	237	65	302

** Less than 5% (three growers or fewer).

Table 7. Distribution (%) of conventional and organic vegetable growers surveyed, by off-farm work, 1994.

Off-farm work by operator (days)	Conventional			Organic		
	Small	Large	All	Small	Large	All
0	59	83	76	54	88	61
1 - 100	8	7	7	20	5	17
101 - 200	10	5	6	12	6	11
201 - 360	23	6	11	14	**	11
Total	100	100	100	100	100	100
Number responding	2009	4572	6581	236	66	302

** Less than 5% (three growers or fewer).

Table 8. Distribution (%) of conventional and organic vegetable growers surveyed, by main source of information for pest control, 1994.

	Conventional (All)	Organic		
		Small	Large	All
Extension advisors	14	14	21	16
Extension publications	11	7	**	6
Farm supply/chemical dealer	37	4	9	5
Commercial scouting service	4	*	**	1
Crop consultant/pest control advisor	12	5	14	7
Processor	10	*	**	1
Other growers	6	23	26	23
Grower association	2	8	**	7
Newsletters, newspapers, trade magazines, special events, or demonstrations	*	24	11	23
Organic certifying agent	*	14	9	13
Total	100	100	100	100
Number responding	471	237	66	303

* Less than 1%.
** Less than 5% (three growers or fewer).

sharply in the use of some of these techniques: 75% of the organic growers surveyed consider pest resistance when selecting plant varieties, compared with 30% of conventional growers; 54% of the organic growers adjust planting dates to control insects and diseases, compared with 16% of conventional growers; and 44% of the organic growers use water management techniques to help control pests compared with 6% of conventional growers (Table 11).

Crop rotation is used by a large proportion of both the conventional and organic growers (74% and 86% respectively, Table 11), although the organic growers may be using more complex rotations. A recent study of the rotation patterns among New York potato growers found that those who rotate from potatoes after only a year or two believed that it helped reduce plant pests and diseases (Gillespie et al., 1996).

Most organic and conventional vegetable growers also scout or monitor their crops for the presence of crop pests; 97% of the organic and 83% of the conventional growers scouted in 1994 (Table 11). Many conventional growers use crop scouting as a way to improve efficiency of synthetic pesticide use. The operator or family member scouted on 86% of the organic farms, compared with only 45% on the conventional farms. Commercial scouting services and other professional consultants and chemical dealers were used by 20% of the conventional growers.

A nutrient practice that could be compared directly between the organic and conventional growers is the use of non-commercial manure and lime. Far more organic growers (64%) used noncommercial manure as a source of plant nutrients in 1994 than did conventional growers (14%, Table 11). Lime was used by the same proportion of both organic and conventional growers (28%).

Large and small organic growers used most of these pest and nutrient practices to a similar degree (Table 11). Water management and beneficial organism releases are an exception, with large organic growers using them more heavily. Large organic growers also use employees and crop consultants or commercial scouting services more frequently to scout their fields.

Pest and nutrient materials used by organic growers

Although organic farming systems rely primarily on biological and cultural management tools and organic processes for pest and nutrient management, most certifying agencies allow growers to use certain materials. Synthetic materials have been avoided in organic farming systems because of the risk of ecological disruption of soil nutrient cycles and plant and animal populations. For example, they may reduce the soil's ability to recycle organic

Table 9. Distribution (%) of organic vegetable growers surveyed, by main marketing channel reported, 1994.

Marketing channel	Small	Large	All
Grower cooperative	10	3	9
Packer or shipper	*	14	3
Broker	3	21	7
Processor	*	17	4
Grocery wholesaler or distributor	10	26	14
Grocery retailer	11	6	10
Directly to consumer[1]	60	12	49
Any other	5	**	4
Total	100	100	100
Number responding	237	66	303

[1] Roadside stands, farmers markets, etc.
* Less than 1%.
** Less than 5% (three growers or fewer).

Table 10. Distribution (%) of organic vegetable growers, by year first certified.

	Small	Large	All
1970 - 75	3	**	3
1976 - 80	4	5	4
1981 - 85	12	12	12
1986 - 90	50	52	50
1991 - 94	32	29	31
Total	100	100	100
Number responding	237	66	303

** Less than 5% (three growers or fewer).

matter, or may induce resistance in crop pests. Natural materials have generally been allowed, including the restricted use of a small number that are toxic to some nontarget species, such as some botanical pesticides. Botanicals have generally been allowed in emergencies only, such as when crop loss is threatened by a large pest population that other methods have failed to control. Frequently, documentation of the circumstances of their use is required.

The various certifying agencies have differed somewhat on which materials they prohibit, and on which allowed materials are restricted in their use. The National Organic Production Act of 1990 required that a uniform "National List" of materials be compiled to clarify which synthetic production materials should be exempted from prohibition and which natural production materials should be prohibited in producing and handling organic foods (NOSB, 1995b). Although NOSB's review process for materials is ongoing, this board has already reviewed most of the materials used by organic growers and submitted its final recommendations to USDA.

The Organic Foods Production Act required that the NOSB consider the following seven criteria in evaluating materials for inclusion in the National List:

- the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems
- the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment
- the probability of environmental contamination during manufacture, use, misuse or disposal of such substance
- the effect of the substance on human health
- the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms, crops and livestock
- the alternatives to using the substance in terms of practices or other available materials
- its compatibility with a system of sustainable agriculture (NOSB, 1995b).

Strychnine and tobacco dust are examples of the natural materials that NOSB recommended be excluded from the list, while synthetic soaps, elemental sulfur, pheromones, and plastic mulch, for example, are among the synthetic materials that have been recommended for inclusion (NOSB, 1995a,c).

The certified organic growers surveyed in 1994 reported little use of materials for insect and pest management other than the biological products discussed in the previous section. We examined NOSB recommendations for the National List of materials—natural materials that are recommended to be prohibited in organic farming and synthetic materials that are approved for use—to see whether any of the products that the organic growers reported using would be affected by these recommendations.

We also examined the current guidelines of several major certifying agencies in different parts of the U.S. that provide certification services—California Certified Organic Farmers (CCOF), Oregon Tilth, and the Organic Crop Improvement Association (OCIA) which has chapters in 23 states—to see how consistent they are in their recommendations on these materials and whether they differ from NOSB recommendations (MacCormack, 1992); OCIA, 1995; CCOF, 1996). These certification agencies are similar in their current recommendations on the use of these materials, and NOSB recommendations are different from current recommendations only for a few materials.

Materials for insect management

For insect management, the certified organic growers reported using synthetic soaps (8% of the growers), the combined forms of rotenone and pyrethroids (Pyrellin EC) (6%), rotenone (5%), and diatomaceous earth (3%) (Table 12). More large organic growers reported using resistant

Table 11. Various pest and nutrient management practices used by conventional and organic growers, 1994 (%).

	Conventional (All)	Organic		
		Small	Large	All
Practices used				
Scouting for pests	87	96	100	97
Use crop rotation	74	85	91	86
Use noncommercial manure[1]	14[2]	63	67	64
Select plant varieties considering pest resistance	30	73	80	76
Use water management to help control pests	6	41	61	44
Adjust planting dates to help control pests	16	53	59	54
Use beneficial organisms	5	42	61	46
Plant crops to encourage beneficial organisms	na	58	59	58
Use Bt (*Bacillus thuringiensis*)	12[3]	12	15	13
Use lime	28[2]	29	27	28
Use micronutrients	44[2]	37	38	37
Who did most of the scouting?				
Operator or family member	45	92	64	86
Employee	2	3	12	5
Crop consultant or commercial scouting service	10	*	15	4
Farm supply or chemical dealer	10	*	**	*
Other	15	*	8	2
No scouting done	17	4	*	3
Total	100	100	100	100
Number responding (unless otherwise indicated)	471	237	66	303

[1] Excludes commercially prepared manure.
[2] Sample size = 6605.
[3] Sample size = 4831.
* Less than 1%.
** Less than 5% (three growers or fewer).
na Not available.

varieties, beneficial organisms, synthetic soaps and Pyrellin EC than did small organic growers. Sabadilla and other minor materials were used by fewer large organic growers. These minor materials, including cryolite (sodium fluoaluminate), sabadilla, garlic, elemental sulfur, natural pyrethrums, fish products, seaweed, and Texas Pete (a food product made from hot chili peppers that is on EPA's list of low-risk pesticides) were used by less than 2% of both the large and small organic growers. In contrast, conventional vegetable production in the U.S. usually relies on synthetic pesticides to control insects and other pests.

The four botanical pesticides that growers reported using (Pyrellin EC, rotenone, pyrethrums, and sabadilla) are all currently allowed only on a restricted basis by CCOF, Oregon Tilth and OCIA. Similarly, the NOSB (1994) recommended that these botanical pesticides be allowed under the following restrictions: they shall not be the primary method of pest control; they shall be used in the least toxic and least ecologically disruptive way; EPA safety precautions, preharvest intervals, worker re-entry periods and other rules must be followed; and their acceptability should be reviewed in five years after additional safety data have been collected.

The use of cryolite is also restricted by CCOF, Oregon Tilth, and OCIA, and CCOF prohibits the use of the synthetic form of cryolite. Of the insect control materials that the organic vegetable growers reported using in 1994, only cryolite has NOSB recommendations that differ from the current certifying agency guidelines. NOSB recommended that both natural and synthetic cryolite be prohibited for use in organic systems (NOSB, 1996). The other materials that the organic growers reported using are generally allowed on an unrestricted basis by the certifying agencies, and NOSB recommendations were similar. NOSB did recommend prohibiting several other natural insect control materials, including strychnine, nicotine, and arsenic, but none of the organic vegetable growers surveyed in 1994 reported using them.

Materials for disease management

For disease management, the organic growers reported using elemental sulfur (5%), copper products (3%), and hydrogen peroxide (2%) (Table 12). However, much larger proportions of the larger growers used sulfur and copper products (18.2 and 9.1%) compared with the small growers (1.5 and 2.5%). The other products that the growers reported using (Bordeaux mixture, sodium bicarbonate, seaweed, herbal preparations, lime sulfur, biodynamic preparations, sugar, newspapers, elbon rye, and granite sand) were used by less than 2%.

CCOF, Oregon Tilth, and OCIA restrict the use of elemental sulfur and copper products, and two of those certifiers also restrict the use of lime sulfur. The other materials that the growers reported using are all allowed by these certifiers. NOSB recommendations are similar to these requirements of certifiers.

Nutrient sources

Organic farming systems focus on soil health as the primary criterion for evaluating mineral fertilizers, and organic farmers use legume crops, green manuring, animal manuring, composting, and crop rotation as the major sources of nutrients (MacCormack, 1992). In 1994, 78% of the surveyed organic vegetable growers reported using animal manure, 77% reported using legume crops, and 61% reported using compost (Table 12). Fish products are used by 20%, and vegetable and animal meal were

Table 12. Materials used by surveyed organic vegetable growers, 1994 (% using).

	Small	Large	All
Materials used for insect management			
Resistant varieties	59.9	71.7	62.4
Beneficial organisms	41.8	60.6	45.9
Bacillus thuringiensis (Bt)	12.3	15.1	12.9
Soaps, synthetic	5.0	18.1	8.0
Pyrellin EC (pyrethrums plus rotenone)	2.9	15.2	5.6
Rotenone	6.7	*	5.3
Diatomaceous earth	3.3	**	3.0
Pyrethrums, naturally occurring forms	1.2	**	1.7
Cryolite (sodium fluoaluminate)	*	**	1.4
Sabadilla	1.6	*	1.4
Garlic	*	*	1.0
Sulfur, elemental	1.2	**	1.0
Fish	*	*	*
Seaweed	*	*	*
Texas Pete	*	*	*
Materials used for disease management			
Resistant varieties	73.4	80.3	74.9
Beneficial organisms	25.7	25.8	25.7
Sulfur, elemental	1.5	18.2	5.3
Copper products	2.5	9.1	2.9
Hydrogen peroxide	2.1	**	2.3
Bordeaux mixes	*	**	1.3
Sodium bicarbonate	1.2	*	1.0
Seaweed	*	*	*
Herbal preparations	0	**	*
Lime sulfur	*	*	*
Biodynamic preparations	*	*	*
Sugar	*	*	*
Newspapers	*	*	*
Elbon rye	*	**	*
Granite sand	*	*	*
Nutrient-containing materials			
Basic materials			
Manure	77.2	78.2	77.6
Legumes	77.6	74.2	76.9
Compost	64.6	50.0	61.4
Supplemental materials			
Fish products	21.1	15.1	19.8
Animal meal	13.9	15.1	14.2
Vegetable meal (cottonseed, soybean)	9.9	**	7.3
Aquatic plant extracts (kelp products)	6.3	**	5.6
Chilean nitrate/sodium nitrate	*	19.7	4.9
Nitrogen-fixing microorganisms	*	*	*
Bacterial inoculants	*	**	*
Manure tea	*	**	*
Plantone (mixed organic fertilizer (3-2-3))	*	*	*
Oyster shell	*	*	*

* Less than 1%.
** Less than 5% (three growers or fewer).

used by 7 and 14%, respectively. Other nutrient sources (kelp, Chilean nitrate, microorganisms, mixed organic fertilizers, and oyster shells) were used by about 5% or fewer. Few large growers use compost and fish products, while many use Chilean nitrate.

CCOF, Oregon Tilth, and OCIA allow the use of all these materials with few restrictions, except for Chilean nitrate, and NOSB recommendations are similar. For Chilean nitrate, OCIA currently prohibits the use of this material because of high sodium content and lack of positive effects on soil building (OCIA, 1995), and CCOF and Oregon Tilth allow its use only with restrictions. NOSB recommends allowing the use of Chilean nitrate but restricting it to no more that 20% of the total nitrogen supplied to a crop (NOSB, 1995).

Concluding comments

Increasing consumer demand for "green" products, along with implementation of the National Organic Food Production Act, could push the rate of growth of organic food sales—over 20% annually throughout the 1990s—even higher. Results from USDA's 1994 Organic Vegetable Survey indicate that ecologically based practices—cultural and biological pest management practices and organic processes for nutrient management—are the primary focus of the farming systems used by certified organic growers, and the survey highlights other industry features that have drawn consumer interest. Over three-quarters of the surveyed certified organic growers have small farms, and most of these sell their crops directly to the consumer. The need for additional data collection on the organic segment of U.S. agriculture will continue as the industry expands. In particular, data gaps on commodity diversification, prices, economic performance and other issues need to be filled.

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Agriculture is to Blame for Much of the Country's Polluted Waters

Runoff from agricultural lands is the biggest source of pollution in the rivers and lakes surveyed in 1996, according to an EPA report. *National Water Quality Inventory: 1996 Report to Congress* reports water quality conditions in rivers, lakes, estuaries, wetlands, coastal waters, the Great Lakes, and groundwater, and found that as of 1996, about 40 percent of the country's surveyed rivers, lakes, and estuaries are too polluted for basic uses, such as fishing and swimming. Agriculture is the most widespread source of pollutants in rivers and streams, the report said; agricultural activities may introduce siltation, nutrients, pesticides, and organic matter that deplete oxygen in surface and ground waters.

Agriculture is also the most widespread source of pollutants in lakes, where agricultural fertilizers and manure from animal operations can be a major source of nutrients. In lakes, reservoirs, and ponds, nutrients and metals are the most widespread pollutants; nutrients are the most widespread pollutants in estuaries.

National Water Quality Inventory is available on the Internet at http://www.epa.gov/305b/.

Natural terrace formation through vegetative barriers on hillside farms in Honduras

Robert J. Walle and Brian G. Sims

Abstract. *The effects of contour live barriers of vetiver and pennisetum on soil erosion were studied on four small farms in south central Honduras. Paired plots were installed and soil erosion measured by changes in the soil surface level of transects 0.3 and 6.0 m up the slope from the barrier. After three years, transects 0.3 m above the barriers significantly retained eroded soil compared with control transects. Soil accumulation by barriers ranged from 2.6 to 11.2 cm, and natural terrace formation (the difference between the barrier and corresponding control transect) ranged from 5.2 to 13.8 cm. No difference was detected between barrier and control for the transects 6.0 m above the barrier. Deposition in front of the barriers and reduction in surface rilling were apparent to farmers. Erosion from up slope on the barrier plots and from both transects in the control sections was not obvious. Direct measurement and farmer observation of sediment deposition by live barriers will help evaluate farmer-identified species for future use. The deposition helps farmers become aware of sheet erosion before the effects of soil degradation on crop yields become grossly apparent and soil fertility restoration becomes too costly for small-scale farmers.*

Key words: contour vegetative barriers, soil erosion, soil conservation, vetiver

With continued high levels of erosion, basic improvements in hillside farming systems will be less effective without soil and water conservation practices. Compared with soil loss from agricultural lands, dramatic damage such as reservoir sedimentation may be more important nationally, but the individual farmer cannot be expected to be concerned about it (Hudson, 1983). The rationale for on-farm soil conservation must relate to the farmer's own land and crops.

Vegetative barriers have become a preferred choice for low-income farmers because they are easy to establish, inexpensive, and effective (National Research Council, 1993). Contour barriers reduce the impact of erosive forces before vegetation covers the soil. Natural terrace formation by live barriers is the starting point for a small-farm technology development project managed by the Silsoe Research Institute (SRI), UK. Once the soil surface on steep hillsides has been stabilized, other innovations such as alternative barrier species, leguminous cover crops, and organic soil amendments can reasonably be considered.

Measurement of erosion involves installing sophisticated, expensive devices, which limits their replication and on-farm evaluation. To improve on anecdotal evidence, simple measurements can be made on-farm, allowing both farmers and researchers to evaluate the effects of live barriers. The objectives of this study were to measure the effectiveness of grass barriers in promoting deposition of eroded soil and natural terrace formation, and to elicit farmer observations for future use in the promotion of soil and water conservation.

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Literature Review

The SRI hillsides farm technology project (Sims et al., 1994) seeks practical solutions to problems in soil and water conservation through on-farm experimentation and farmer participation in the research process. Research is centered on helping to design better soil conservation systems rather than simply assessing the increase of erosion from known natural factors or erosion-inducing practices (Belshaw et al., 1991). The project emphasizes implementing effective soil conservation practices immediately, given the severity of the problem (Lal, 1984).

Information is widely available on soil conservation and management practices in Honduras (Recursos Naturales, 1986; Peace Corps, 1990; Leonard and Margoya, 1993), but adoption has not been widespread. Live barriers are among the soil conservation practices most popular with farmers. The most common species of plants currently in use in the project area are *Pennisetum* spp. and vetiver grass (*Vetiveria zizanioides*) (World Bank, 1990). Farmer perceptions are widely reported, yet much of this information is anecdotal. The lack of measurement and statistical analysis leads many to regard farmer experimentation as simple production experiences rather than experiments (Bentley and Andrews, 1991), which undervalues farmers' insights into technology appropriate to their conditions.

Farmer experimentation is an important part of research and extension in agricultural development efforts (Bunch, 1990), influencing experimental design and increasing farmer-to-farmer exchange (Fujisaka and Garrity, 1991). With the farmer in mind, experimental designs should be simple so that visual conclusions can be made. The results should also be evaluated with respect to the socioeconomic concerns of the farmers (Manavolta and Rocha, 1978). Observation of a technology in action affects the farmers' knowledge (Bentley, 1989) and provides a focal point for farmers to teach researchers about their conditions and criteria (Napier, 1991).

Although soil degradation may not be readily observable, soil deposited in front of a live barrier provides evidence of sheet erosion that might not have been noticed without the barrier. Because it is easily observed and measured, it provides an important and objective link between the erosion process, researchers, and farmers. Area farmers use the formation of natural terraces as a criterion for maintenance of hillside ditches (Bunch and Lopez, 1994). Once natural terraces have formed, farmers consider that maintenance of contour ditches is unnecessary and that this aspect of soil conservation is accomplished.

Materials and Methods

Four farmers in the municipalities of Tatumbla (Francisco Morazán), Güinope, Lavanderos, and Chagüite (El Paraíso), Honduras, participated in this study by installing experimental plots on-farm. Site descriptions are given in Table 1. The cropping system for all plots was maize (*Zea mays*) followed by common bean (*Phaseolus vulgaris*). The soil was prepared by traditional wooden ard plow with a steel share, pulled by a yoked pair of oxen. All experimental plots were farmer-managed. Farmer perceptions focused on the establishment and maintenance of the barriers, the effect on crops, the opportunity cost of land occupied by the barriers, the uses for the vegetative material, and alternative plant species for future barrier use.

Live barriers

Sites were selected for uniformity of slope and soil so that side-by-side paired comparisons could be made between barriers and unprotected plots. Farmers had partially installed live barriers in the previous year: vetiver grass on the Lavanderos site, and 'king grass' (*Pennisetum purpureum* × *P. typhoides*) at the Tatumbla site. Contour barriers of vetiver grass were installed on the Güinope and Lavanderos farms at the beginning of the 1994 cropping season. Contour lines for locating the barriers and control transects were determined with an A-frame level. Barriers were established across half the plot, leaving an unprotected section as control on the same contour line. In the treatment plots, plantlets of vetiver were planted at 15-cm intervals along the contour. The distance between live barriers, 6.5 m, was decided by the farmers. This was greater than recommended (Leonard and Margoya, 1993), but was chosen because the farmers were concerned about cropping space lost to barriers.

Table 1. Environmental characteristics of study sites.

Location	Elevation (m)	Soil Great Group	Slope (%)
Güinope	1300	Lithic Ustorthent	48
Lavanderos	1250	Typic Ustorthent	25
Chagüite	1250	Typic Ustorthent	31
Tatumbla	1550	Lithic Haplustalf	25

Table 2. Cumulative soil loss(-) or accumulation(+) (cm) from transect 0.3 m above barrier and from corresponding control transect, 1994-96. Confidence intervals are for α = 0.05.

Location		1994	1995	1996
Tatumbla	Barrier	−1.3 ± 1.4	+7.4 ± 1.3	+11.2 ± 3.1
	Control	−1.8 ± 1.0	−0.6 ± 1.4	−1.9 ± 2.2
Lavanderos	Barrier	−1.1 ± 0.8	+1.6 ± 0.9	+2.6 ± 1.5
	Control	−0.7 ± 0.8	−0.3 ± 1.2	−2.6 ± 2.9
Chagüite	Barrier	−0.8 ± 2.0	+3.4 ± 1.9	+5.0 ± 3.0
	Control	−0.8 ± 1.0	−2.2 ± 1.1	−4.7 ± 2.3
Güinope	Barrier	−3.2 ± 0.9	+4.7 ± 1.1	+6.4 ± 1.7
	Control	−4.6 ± 1.6	−2.5 ± 6.8	−7.4 ± 7.3

Soil surface measurements

Benchmarks consisting of steel bars 1.25 m × 2.5 cm were installed along contour lines at 4 m intervals in barrier and control sections. In the live barrier plots, the benchmarks were located 0.3 m and 6 m up the slope from the barriers to measure soil deposition or erosion at these slope positions. Benchmarks were installed on the same contour lines in the control plots. To measure soil loss or accumulation, a 5 mm diameter steel cable was fastened to permanent reference points between benchmarks. The distance from the cable to the soil surface was measured to the nearest mm at 30-cm intervals along the cable using a plumb-bob. Two transects for each treatment and slope position were measured. To express results in terms easily presented to farmers, simple confidence intervals (Gómez and Gómez, 1984) were used to compare treatment means at individual locations.

Results and Discussion

Average soil accumulations or losses from the transects are presented in Tables 2 and 3. During the first year, no differences were measured between the barrier and control transects 0.3 m above the barrier. By the end of 1995, barriers in Tatumbla and Chagüite showed significant accumulation, and all sites showed a significant difference by the end of 1996 (Table 2). The greater variation observed in the control plot at the Güinope site is explained by rill erosion that was not present in the live barrier plots.

In the transects 6 m above the barrier (Table 3), only the Güinope site showed

Table 3. Cumulative soil loss(-) or accumulation(+) (cm), from transect 6.0 m above the barrier and from corresponding control transect, 1994-96. Confidence intervals are for $\alpha = 0.05$.

Location		1994	1995	1996
Tatumbla	Barrier	−1.2 ± 1.0	+1.2 ± 1.7	+0.9 ± 3.3
	Control	+0.3 ± 1.0	−0.4 ± 0.9	−2.0 ± 2.9
Lavanderos	Barrier	−3.6 ± 0.8	−3.6 ± 1.1	−4.9 ± 2.0
	Control	−2.2 ± 1.4	−4.3 ± 1.3	−3.5 ± 1.6
Chagüite	Barrier	−6.8 ± 1.8	+1.4 ± 1.8	−8.3 ± 4.6
	Control	−1.6 ± 1.9	−3.9 ± 1.5	−11.8 ± 5.2
Güinope	Barrier	−4.6 ± 1.5	−8.1 ± 1.8	−12.6 ± 3.2
	Control	−1.4 ± 1.2	−1.2 ± 1.2	−2.4 ± 2.4

a difference between treatments, with the loss of soil depth greater with the barrier treatment. Without the retention of the barrier, soil from up slope may deposit along the control transects, reducing the change in surface level from erosion.

No difference was detected between slope positions of 0.3 m and 6 m within control transects. Individual measurements of soil movement within one year varied mainly with the disturbance from farmers' typical cultivation practices. Differences between treatments became significant as this variation decreased.

Natural terrace formation

Terraces form naturally from the loss of soil on the upper portion of the slope between barriers (Table 3) and its subsequent accumulation by the live barrier below (Table 2). This process is represented in Figure 1. Although soil erosion still occurred between the live barriers, they were effective at keeping the eroded soil from moving further down the slope, compared with the corresponding transect on the same slope position without live barriers. This became apparent as the barriers became established and the initial gaps between plantlets closed.

Farmer perceptions

Farmers noticed the accumulation of soil in front of the barriers by the second year. The loss from the control plots and from the transect 6 m above the barrier was not as obvious. Farmers noted that rills stopped at the barrier, but continued down slope on the control plot. This effect was most pronounced on the site with the steepest slope, Güinope (Table 1).

While agreeing that the live barriers conserve soil, farmers are primarily interested in other aspects of the barriers. These include fodder for use or sale, production of fruit or sugar cane, the loss of potential cropping area, and the maintenance required. These all affect the farmer's decision on which plant species to use for live barriers. Farmers with livestock to feed generally choose pennisetum, while other farmers generally choose vetiver because it occupies less space, forms a tighter barrier, and is more vigorously promoted. The lack of uses for the vegetative material of vetiver is a principle concern among most farmers. Some farmers with barriers of pennisetum are replacing them with vetiver because pennisetum has invaded cropland by up to 2 m. This change is due to farmer experimentation and experience, and is not an indictment of previous extension methods. Although farmers agree that vegetative barriers are effective in controlling soil erosion, spontaneous adoption is not common. Most existing barriers resulted from promotion by one of the agencies working in the project area, and not from concern for erosion control.

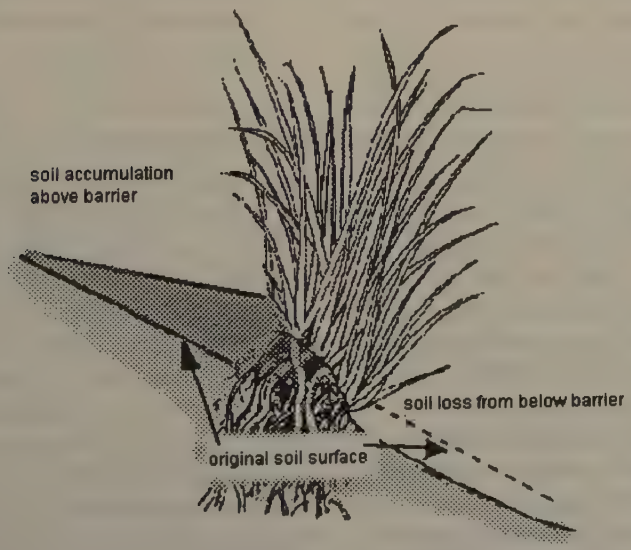

Figure 1. Natural Terrace formation (Adapted from World Bank, 1990).

Summary

Within a live barrier system, soil still erodes from below one barrier and deposits in the front of another downslope. This process is observable and easily measured. When used as an indicator of soil conservation, different barrier species of interest to the farmer may be evaluated simply. The transect in front of the barriers represents the most visible aspect of soil conservation and is of most value in eliciting farmer observation and participation. Although less accurate than runoff plot measurements of soil erosion, simple soil surface measurements of this transect provide information relevant to the farmer at less cost.

This simple method of documenting deposition can easily be replicated by farmers and extension agents to determine the effectiveness of live barriers. Farmers in the project area have lost interest in the initial favorite barrier species, *Pennisetum*, and have concluded that it is desirable to have a variety of species such as sugarcane, banana, and pineapple (Lopez et al., 1995). The simple installation of benchmarks in front of the farmer-selected

barriers will allow soil conservation workers and, more importantly, farmers to compare other barrier species, and lead to better collaborative research.

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Research Title Clears Conference; Fund for Rural America Reduced

A House-Senate conference committee recently approved the "Agricultural Research, Extension, and Education Reform Act of 1998," or research title, which reduced the annual spending for the Fund for Rural America. The Fund for Rural America previously had been funded at $100 million a year for three years, with $100 million left for Fiscal Years 1999 and 2000. Under the new research title, that $200 million would be spread out over five years, and an additional $100 million would be added to the five-year total. This means the Fund would receive $60 million a year for the next five fiscal years, bringing its total to $300 million, but reducing the Fund's annual allocation for the next two years. The annual amounts available within the Fund would be $20 million for research, $20 million for rural development, and $20 million for the Secretary of Agriculture to allocate between research and rural development.

The research title includes a new competitive grants program called the "Initiative for Future Agriculture and Food Systems," which would allocate $600 million over five years. The program has six priorities: food genome mapping; biotechnology; natural resource management, including precision agriculture; food safety and food technology; new uses and products for agriculture commodities; and farm profitability for small and medium-sized farms, which was added to the program at the urging of the Wallace Institute and other sustainable agriculture organizations.

Erosion effects on soil moisture and corn yield on two soils at Mlingano, Tanzania

A.J. Tenge, F.B.S. Kaihura, R. Lal, and B.R. Singh

Abstract. *Soil erosion is a major threat to sustaining agricultural production in Tanzania. However, quantitative information is scanty on its effects on yields of major crops for principal soils and management practices. We conducted this study to determine erosion effects on soil moisture, related properties and corn yield on Tropeptic Haplustox and Ultic Haplustalf soils at Mlingano in Tanzania. Four erosion classes (least, slight, moderate, and severe) on Tropeptic Haplustox and three erosion classes (slight, moderate, and severe) on Ultic Haplustalf were established according to the thickness of the Ap horizon under natural field conditions. Accelerated soil erosion reduced soil moisture content, soil organic carbon, available water capacity and water use efficiency. Mean volumetric soil moisture content (average of both soils) during the growing season was 23.3% for severe, 24.8% for moderate, and 25.7% for slight erosion. Mean soil organic carbon content was 1.15% for severe, 1.64% for moderate and 1.97% for slight erosion. Mean available water capacity was 2.6 cm for severe, 3.5 cm for moderate, and 4.0 cm for slight erosion. Soil bulk density and excessive degree days of soil temperature above 25°C increased with severity of erosion. These adverse changes accentuated constraints on crop growth and reduced corn (Zea mays) yield on severely eroded soil by 45% and 59% for Tropeptic Haplustox and Ultic Haplustalf soils, respectively. The water use efficiency of corn was 21.6 kg ha^{-1} cm^{-1} in the least eroded class versus 17 kg ha^{-1} cm^{-1} in the severely eroded class for the Tropeptic Haplustox, and 23 kg ha^{-1} cm^{-1} in the slightly eroded and 18.1 kg ha^{-1} cm^{-1} in the severely eroded class for Ultic Haplustalf.*

Key words: soil erosion, productivity, soil physical properties

Accelerated soil erosion affects crop growth through its impact on the soil moisture regime (Lal, 1987) and nutrient availability (Olson and Nizeyimana, 1988). Soil moisture and its energy state in the soil are important for plant growth because many soil processes and properties depend upon it. Soil moisture governs the gaseous exchange and composition of soil air, and the soil's consistency, plasticity, strength, compactability, penetrability, stickiness, and trafficability (Hillel, 1982). It also regulates ionic solubility and the composition of the soil solution.

Soil erosion causes loss of soil organic carbon and clay colloids, which in turn adversely affects the soil's structure and hydrological properties. Poor structure decreases infiltration capacity, increases runoff, reduces water availability to plants, and lowers crop yields (Rhoton and Tyler, 1990; Mokma and Sietz, 1992; Lal, 1995a). For eight soils in three ecoregions of Tanzania, Kilasara et al. (1995) observed that crop yields were about 30% lower on severely eroded than on slightly eroded soil. At one site the reduction was as much as 75%.

Tanzania depends on agriculture for its economic and social development. Agriculture contributes about 50% of Gross Domestic Product and 50% of all exports (Express, 1993). About 85 to 90% of Tanzania's labor force is engaged in agricultural activities, with small-scale farming accounting for 70 to 75% of total food production (Express, 1993). The total land area is 94.5 million ha, of which only 3.4 million ha is arable land (Lal, 1995b). Therefore, land is a finite resource that must be safeguarded for the survival of present and future generations.

Soil erosion is a major threat to agricultural production in Tanzania, where it is a serious hazard on sloping lands and on the semi-arid plains of the central region (Rapp et al., 1972; Ngatunga, 1984). Usambara uplands are among the areas most affected by soil erosion in Tanzania (Helberg, 1980; Kalaghe et al., 1988; Ngatunga, 1984). Besides reducing crop yields, erosion has caused deterioration of stream water quality. Silting of waterways has become a common problem during the rainy season, resulting in shortages in domestic water supplies.

Despite the severe effects of erosion on crop yield, quantitative information is scarce. Many studies in Tanzania have concentrated on the amount and rates of soil loss under different management practices (Kaihura et al., 1994b; Ngatunga, 1984). These studies have generated information that is important for understanding

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soil erosion processes and developing erosion control measures. However, their usefulness and practical importance would be enhanced by translating data on the rate of soil erosion into crop yield losses, which are of primary importance to farmers.

The major objective of this study was to determine quantitatively the effects of soil erosion on soil moisture, related soil properties, and yields of corn (*Zea mays*) grown on two principal soils of the Mlingano region in Tanzania. The study also developed a quantitative relationship among soil erosion, soil properties, and corn yield so that the results may be used to predict yield losses due to soil erosion elsewhere in the region. This information on erosion-productivity relationship may motivate farmers and policy makers to invest in erosion control measures.

Materials and Methods

Study area

The study was conducted at Mlingano Agricultural Research Institute, located at 5°10'S and 39°52'E on foot slopes of the east Usambara mountain ranges, at an elevation of about 180 m above sea level. The climate of Mlingano is tropical wet-and-dry as described by Koppen (Ahren, 1991), with slight annual fluctuations in ambient temperature and relative humidity. The mean annual rainfall of 1150 mm is received in two seasons: a season of short rains from September to December, and a season of long rains from March to June. This study was conducted during the long-rain season of 1994 on two predominant soils of the region that are classified respectively as Tropeptic Haplustox and Ultic Haplustalf (Soil Science Society of America 1990) or Rhodic Ferralsol and Chromic Luvisol (FAO/UNESCO, 1988). Because of an increase in clay content from surface to the subsoil (Table 1), soil erosion exposes the clayey subsoil and increases the surface clay content.

The Usambara uplands produce almost all the vegetables and temperate fruits marketed in the Tanga municipality and in a large part of Dar es Salaam, the capital city, as well as in neighboring Kenya. The eastern range of the Usambara mountains is an important watershed for the Zigi and Mkulumuzi Rivers, which supply water for Tanga municipality and various sisal estates in the region. Farther to the east and central parts of Usambara are the Umba and Rwengera Rivers, respectively. Valleys along these two rivers have good potential for irrigation and urban water supply. Major crops grown in the region are sisal (*Agave sisilana*), banana (*Musa spp.*), corn, cowpea (*Vigna unguiculata*), temperate fruits, and upland rice (*Oryza sativa*) in valley bottoms.

Table 1. Variation of clay content (%) with profile depth (cm) for the Tropeptic Haplustox and Ultic Haplustalf.

	Clay Content (%)	
Depth (cm)	Tropeptic Haplustox	Ultic Haplustalf
0-28	66	44
28-42	72	47
42-66	70	61
66-87	73	57
87-137	73	65

Many farmers in Usambara have small farms (2 to 5 ha), which eventually degrade because of inappropriate farming practices that accentuate rainfall erosion (Ngatunga, 1984; Kaihura, 1991). These practices include planting of row crops up and down the slope, burning of crop residues after harvest, uncontrolled grazing, lack of suitable crop rotation, inappropriate tillage practices such as flat cultivation on steep slopes without any conservation measures, and none or low rates of fertilizer application. Therefore, alternatives to the present way of farming need to be examined, with an emphasis on practices that conserve soil and water and enhance soil fertility.

Site selection and characterization

To identify study sites, we visually assessed field surface conditions for evidence of slope gradient and past erosion. Two sites were selected for identification of different erosion classes. Each was 1 ha and represented the soil erosion problems on Ultic Haplustalf and Tropeptic Haplustox soils. The average slope for the Tropeptic Haplustox and Ultic Haplustalf sites was 8% and 10%, respectively.

We surveyed the soil by excavating and describing one profile pit at each site to about 1-m depth (Tenge, 1995). We also excavated and described mini-pits (30, 60, and 30 cm in width, length, and depth, respectively) at grid intervals of 5 m. The topsoil depth (TSD), color, and consistency of the Ap horizon and the immediate underlying horizon of each mini-pit was described. Depending on the depth of the Ap horizon, erosion was classified as severe (Ap <15 cm), moderate (Ap = 15-20 cm), slight (Ap = 21-25 cm), or least erosion (Ap >25 cm). The minimum plot size demarcated on each erosion class was 5 × 4 m, with three replicate plots for each erosion class. To simulate farming conditions and eliminate masking effects of management practices, all plots were conventionally tilled (flat cultivation) and received no fertilizers or other amendments.

Soil properties

We measured soil moisture content, bulk density, particle size distribution, available water capacity, SOC, and soil temperature. Selected soil properties were measured twice during the growing season, except soil moisture and temperature, which were measured weekly and daily, respectively. We selected these properties because of the size of their influence on other soil properties and crop growth. All soil properties were measured at 0-30 cm depth.

Soil moisture content

We measured volumetric soil moisture content using a precalibrated Time Domain Reflectometry (TDR) moisture meter (Topp, 1980). To determine moisture

content, 30-cm deep holes were made using a probe guide. The probe was installed in the hole, and readings taken at the predetermined time. This procedure was done weekly throughout the growing season.

Soil bulk density

We measured soil bulk density with a core sampler (Blake and Hartge, 1986). Samples were taken by pressing a core into the soil to an incremental depth of 0-15 cm and 15-30 cm. The core was gently removed, carefully trimmed, weighed, and dried in an oven at 105°C. The oven-dry weight was divided by the volume of the core to obtain the bulk density (Mg/m^3).

Particle size distribution

We determined particle size analysis by the pipette method (Gee and Bauder, 1986). Soil was sieved and pretreated with hydrogen peroxide and hydrochloric acid and then dispersed with sodium hexametaphosphate (4% solution) and sodium carbonate (1% solution). The particle size separates were determined according to the International Society of Soil Science (ISSS) system for clay (<0.002 mm), silt (0.002-0.02 mm), and sand (0.02-2.0 mm).

Soil moisture retention characteristics and available water capacity

We determined soil moisture retention properties by equilibrating the core samples at various suctions using a pressure plate extractor (low suction), a pressure membrane apparatus (high suction), and a compressor (Klute, 1986). Same core samples were also used for bulk density determination as described before. The available water capacity (AWC) was calculated as the difference in moisture contents between the moisture contents at field capacity (0.03 MPa suction) and permanent wilting point (1.5 MPa suction).

Soil organic carbon (SOC)

We determined SOC by the wet dichromate digestion method (Nelson and Sommers, 1986). The soil sample was digested in a 60:40 mixture of sulfuric and phosphoric acids containing potassium dichromate and titrated with ammonium ferrous sulfate using diphenylamine indicator. SOC (%) was calculated by:

$$SOC = [(B-A) \times N \times 0.396 \times MC]/W \qquad \text{(Eq. 1)}$$

where B is the ammonium ferrous sulfate used for the blank titration (ml), A is the ammonium ferrous sulfate used for the sample (ml), N is the normality of ammonium ferrous sulfate, W is the weight of the sample (g), and MC is a moisture correction factor.

Soil temperature

We measured soil temperature by using mercury-in-glass thermometers installed in the soil at 5 and 30-cm depths (Sterling and Jackson, 1986). To avoid direct solar radiation, the thermometer stem was covered by aluminum foil. Temperature was read eight times in 24 hours, at 3, 6, 9, 12, 15, 18, 21, and 24 hours for 27 days during the growing season. Excessive degree days was calculated as the sum of all temperature differences above or below 25°C (Chang, 1968).

Weather and crop data

We obtained the amount and distribution of rainfall during the growing season (March-June) from the automatic recording rain gauge (Ahren, 1991) installed at a representative site for the two fields. Evapotranspiration was determined from a drainage lysimeter using the water balance technique (Hanks and Aschroft, 1980). One lysimeter was installed at each site within the field. The lysimeter consisted of a rectangular, watertight tank made of sheet metal, 2.3 m long, 1.5 m wide, and 1.2 m deep, with an opening on the top and bottom sides for collecting runoff and deep percolation, respectively. Soil used in the lysimeter was dug from the pit in which it was installed. The soil was filled layer by layer in the lysimeter in the same order as it occurred naturally, and was packed to approximately the same bulk density. Corn was planted in the lysimeter with the same management practices as in the surrounding field. Runoff and deep percolation were collected, measured, and recorded after each rainfall event. Amount of moisture stored in the soil was measured using the TDR moisturemeter, as described previously. Evapotranspiration was estimated by the water balance approach using:

$$P = RO + Ds + ET + Dp \qquad \text{(Eq. 2)}$$

where P is precipitation, RO is run-off, Ds is change in moisture storage, Dp is deep percolation, and ET is evapotranspiration, all in mm.

Evapotranspiration for January and February was estimated from the weather data using a computerized Penman model called Cropwat (FAO, 1984). Grain yield and mean weights of 100 seeds were determined at maturity, and water use efficiency was computed by dividing grain yield by evapotranspiration for each treatment.

Data analysis

We used analysis of variance to evaluate the statistical significance of the treatment effects (Steel and Torrie, 1980). Least significant difference (LSD) at the 5% significance level was used to compare the treatment means. We used multiple regression analysis to develop quantitative relationships among soil erosion, selected soil properties, and crop yield. In developing the multiple regression model, we considered crop yield a dependent variable and soil properties as predictor or independent variables. Interaction between predictor variables was considered by including their product as an independent variable (Devore and Peck, 1993).

The combination of dependent and predictor variables that gave the highest value of coefficient of determination (R^2) was considered the best model. We assessed the validity of the model from the differences between predicted and observed values.

Results and Discussion

Amount and distribution of rainfall

Rainfall amount, distribution, and crop evapotranspiration are shown in Table 2. There was a moisture deficit in January (-165 mm), March (-100 mm), and June (-15 mm). However, the moisture deficit was not very critical during this period because it did not coincide with the peak moisture demand for corn (tasselling stage

Table 2. Rainfall and evapotranspiration (mm) of corn at Mlingano, Tanzania, January-June 1994.

	Evapotranspiration (ET)	Rainfall	(Rainfall-ET)
January	175	10	-165
February	150	230	+80
March	145	45	-100
April	140	250	+110
May	130	280	+150
June	110	95	-15
Total	850	910	+60

Table 3. Mean-erosion induced changes in selected soil properties for two soils at 0 to 30-cm depth.

Soil Type	Erosion Class	Sand (%)	Silt (%)	Clay (%)	Organic Carbon (%)	Bulk Density (Mg/m^3)
Tropeptic Haplustox	Severe	28.0a[1]	6.0a	66.0a	0.9a	1.4a
	Moderate	29.0a	7.3a	63.7ab	1.2a	1.4a
	Slight	26.7a	10.6b	62.7b	1.2b	1.4a
	Least	28.5a	10.3b	61.0b	2.2c	1.3b
	$LSD_{.05}$	3.1	2.7	2.9	0.4	0.1
Ultic Haplustalf	Severe	35.8a	5.7a	58.5a	1.4a	1.5a
	Moderate	33.8a	7.7a	58.5a	2.1b	1.4ab
	Slight	34.5a	12.0b	53.5b	2.7b	1.4b
	$LSD_{.05}$	2.9	2.5	2.1	0.4	0.1

[1] Means followed by the same letter within a column are not significantly different.

in May). Surplus soil moisture was observed in February, April, and May. The moisture balance calculated from these results shows a surplus of 60 mm for the season. These data suggest that soil moisture deficit, a serious constraint for these soils, may be alleviated through adoption of appropriate tillage methods (conservation tillage), mulch farming, and cropping systems.

Soil and water measurements

Particle size distribution (texture). Table 3 shows that the clay content of the surface layer increased from 61% for the least eroded class to 66% for the severely eroded class in the Tropeptic Haplustox, and from 53.5% in the slightly eroded class to 58.5% in the severely eroded class for the Ultic Haplustalf. This increase may be due to exposure of clayey subsoil by accelerated soil erosion. Silt content decreased from 10% in the least eroded to 6% in the severely eroded class for the Tropeptic Haplustox, and from 12% in the slightly eroded to 6% in the severely eroded class for the Ultic Haplustalf. The decrease may be due to preferential removal of unaggregated silt by runoff.

Soil organic carbon. SOC content decreased with increasing soil erosion (Table 3), from 2.2% for the least eroded to 0.9% for the severely eroded class in the Tropeptic Haplustox, and from 2.7% for the slightly eroded to 1.4% for the severely eroded class in the Ultic Haplustalf. The loss of SOC with erosion is a principal cause of the erosion-induced decline in soil fertility.

Soil bulk density. Soil bulk density increased from 1.3 Mg/m^3 in the least eroded to 1.4 Mg/m^3 in the severely eroded class for the Tropeptic Haplustox, and from 1.4 Mg/m^3 in the slightly eroded to 1.5 Mg/m^3 in the severely eroded class for the Ultic Haplustalf (Table 3). The increase in soil bulk density with erosion may be due to deterioration of soil structure caused by the increase in clay and decrease in SOC, leading to formation of a massive structure.

Field soil moisture content. Weekly measurements of soil moisture in May and June showed significant differences between the least eroded and severely eroded classes, especially during periods of low moisture content (Table 4). No significant differences were observed when the soil moisture content was high. For instance, significant differences in moisture content between the eroded and least eroded classes were observed in the first week of June (Week 5), but not in the first week of May (Week 1) because there was enough rainfall to compensate for water lost as runoff. Soil moisture content was always higher in the least eroded than the severely eroded classes throughout the measurement period.

Available water capacity (AWC) and water use efficiency. Table 5 shows the effects of soil erosion class on AWC and water use efficiency. AWC decreased with increased severity of soil erosion, from 4 cm in the least eroded to 2 cm in the severely eroded class for the Tropeptic Haplustox, and from 4.5 cm in the slightly eroded to 3.2 cm in the severely eroded class for the Ultic Haplustalf. This reduction may be due to an increase in clay, decrease in SOC, and deterioration of soil structure. Water was used more efficiently when erosion was less. For example, water use efficiency of corn (in kg ha^{-1} cm^{-1}) was 21.6 in the least eroded compared with 17 in the severely eroded class for the Tropeptic Haplustox, and 23 in the slightly eroded compared with 18.1 in the severely eroded class for the Ultic Haplustalf.

Grain yield

Grain yield was higher in the least eroded than in the severely eroded classes for both soils (Table 6). The yield reduction in the severely eroded class compared with the least eroded was about 45% for the Tropeptic Haplustox and 59% for the Ultic Haplustalf. The decrease may be due

Table 4: Mean weekly volumetric soil moisture content (%) for 8 consecutive weeks, May-June 1994, for two soils at 0 to 30-cm depth.

Type	Class	Week in May/June 1	2	3	4	5	6	7	8	Mean
Tropeptic Haplustox	Severe	28.0	28.2	18.5	16.0	14.0	17.5	27.2	26.5	22.0
	Moderate	28.5	29.3	24.0	15.6	16.1	19.0	28.0	28.1	23.6
	Slight	28.9	30.0	23.2	20.5	16.5	19.5	28.8	28.4	24.5
	Least	29.0	30.5	25.0	22.0	19.0	20.0	30.0	29.8	25.5
	$LSD_{.05}$	1.3	2.5	1.8*	1.8*	1.2*	1.4*	3.0	3.4	
Ultic Haplustalf	Severe	29.0	31.3	22.0	21.8	14.0	22.0	29.0	28.5	24.7
	Moderate	29.0	32.5	25.0	23.0	17.0	22.1	30.2	29.3	26.0
	Slight	31.0	34.0	26.0	25.0	17.8	22.2	30.0	29.5	26.9
	$LSD_{.05}$	5.5	4.0	3.4*	2.9*	1.1	3.2	1.8	1.3	

*= significant difference

Table 5. Available water capacity (AWC) and water use efficiency of corn for different erosion classes.

Soil Type	Erosion Class	Water Use Efficiency (kg ha^{-1} cm^{-1})	Available Water Capacity (cm)
Tropeptic Haplustox	Severe	17.0a[1]	2.0a
	Moderate	20.3b	3.0a
	Slight	19.7b	3.4a
	Least eroded	21.6b	4.0b
	$LSD_{.05}$	2.0	0.9
Ultic Haplustalf	Severe	18.1a	3.2a
	Moderate	21.3b	4.0b
	Slight	23.0b	4.5c
	$LSD_{.05}$	2.5	0.3

[1] Means followed by the same letter in a column are not significantly different.

Table 6. Effect of soil erosion on corn grain yield.

Soil Type	Erosion Class	Yield (kg/ha)
Tropeptic Haplustox	Severe	1917a[1]
	Moderate	2500ab
	Slight	2972ab
	Least eroded	3500b
	$LSD_{.05}$	1355
Ultic Haplustalf	Severe	1805a
	Moderate	3611b
	Slight	4410c
	$LSD_{.05}$	590

[1] Means followed by the same letter are not significantly different.

to detrimental effects of soil erosion on soil properties such as AWC, SOC, and bulk density (Table 3). The yield reduction of 59% on the Ultic Haplustalf is higher than the 30% yield reduction observed by Kaihura and Mkavidanda (1994a) in a similar study on the same soil and erosion classes, but with high inputs. The reduction in corn yield by 30% shows that the adverse effects of accelerated erosion on these soils can be offset by improved management and supplementary off-farm inputs.

Relationship between erosion and selected soil properties

Eqs. 3 through 6 are regression equations showing the relationships among soil erosion as shown by TSD, soil temperature as excessive degree days above 25°C, SOC, AWC and corn grain yields for the Tropeptic Haplustox.

$$Dy = 120 - 1.92TSD, \quad R^2 = 0.60 \quad \text{(Eq. 3)}$$

$$AWC = 1.14 + 0.17TSD, \quad R^2 = 0.68 \quad \text{(Eq. 4)}$$

$$SOC = 0.05 + 0.06TSD, \quad R^2 = 0.76 \quad \text{(Eq. 5)}$$

$$Ym = 683 + 100TSD + 0.523(Dy \times SOC \times AWC \times TSD), \quad R^2 = 0.87 \quad \text{(Eq. 6)}$$

where Dy is degree days above 25°C, Ym is corn yield (kg/ha), TSD is topsoil depth (cm), SOC is soil organic carbon (%), and AWC is available water capacity (cm).

Eq. 3 shows that degree days are inversely related to the topsoil depth, such that a decrease in TSD of 1 cm results in an average increase in degree days of 1.92, with a coefficient of determination of 0.60. Eq. 4 shows that AWC decreases with decreasing TSD, such that each 1 cm of topsoil loss by erosion reduces AWC by 0.17 cm. Eq. 5 shows that about 76% of the variability in SOC content between different erosion classes is caused by soil erosion, which results in a 0.06% decrease in SOC content for each cm of TSD lost.

Eq. 6 is a multiple regression equation relating corn grain yield to TSD, soil temperature as degree days above 25°C, SOC content, and AWC. The R^2 of 0.87 indicates a strong relationship, so that the

equation can be used to predict yield reduction from different levels of soil erosion for the Tropeptic Haplustox at Mlingano and other regions with similar characteristics. The equations also show that certain soil properties have a drastic influence on other soil properties and corn yield. Therefore, their management is crucial for sustainable corn production in this region.

Conclusions

Erosion adversely affected degree days, SOC, AWC, soil moisture content, and bulk density. These adverse effects reduced corn grain yield by 45% and 59% for the Tropeptic Haplustox and Ultic Haplustalf soils, respectively. This difference between soils in yield response to erosion suggests different critical levels of key soil properties and different management strategies for each soil type. Soil properties, including degree days above 25°C, SOC, AWC, and remaining TSD, were highly correlated with corn grain yield, and therefore can be used to estimate erosion effects on corn yield for Tropeptic Haplustox and Ultic Haplustalf soils at Mlingano and other places with similar conditions.

Recommendations

The high agronomic potential of this ecoregion may be realized by additional research. Alternative tillage and cropping systems that conserve soil and moisture need to be tested and introduced in the area to reverse the declining trend in corn yield caused by soil erosion. Potential alternatives include the following:

- No-till systems need to be adopted in which the crop is sown directly into an untilled seedbed without any primary or secondary tillage. Previous crop residue is left on the surface as mulch.
- Slit or slot tillage involves a narrow slot opened to enhance seed-soil contact for good germination and satisfactory stand establishment.
- Contour ridges may be useful for conserving soil and water. The crop may be planted on the ridge top, along both ridge sides, or in the furrow. The ridges may be newly made every season or maintained from season to season.
- Tie ridges improve the stability of contour ridges by enhancing water infiltration. They involve constructing short cross-ties to create a series of basins to store water.
- A rough seedbed is a cloddy seedbed prepared at the end of rainy season to create large clods and an uneven soil surface. This practice can increase surface detention capacity and protect the soil against erosion.
- Vegetative strips are a useful conservation technique. They involve strips of perennials like banana, quatermalla (*Tripsacum laxum*), or Napier grass (*Pennisetum purpureum*) at specified spacings between rows of corn or other crops. Besides reducing runoff velocity, leguminous plants have the advantage of fixing nitrogen and improving soil fertility, while grasses may be used as livestock feed.
- Introduction of an appropriate agroforestry system is another option. In this system, woody perennials such as fruit trees and shrubs are used on the same land management units as agricultural crops or animals, in a spatial arrangement or temporal sequence. This system can lower soil temperature and reduce soil erosion while improving soil quality and providing fruits, fuel, and timber.

Critical levels of soil properties for different crops and soils need to be established so that soil quality can be checked periodically. Taking the land out of production and adopting restorative measures may be a useful strategy for sustainable management of these soils.

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EPA, USDA Name Food Quality Protection Act Advisory Group

Responding to criticism from industry, environmentalists, and public health advocates, the EPA and USDA have established a Tolerance Reassessment Advisory Committee to advise the agencies on implementation of the Food Quality Protection Act. The committee will explore helping EPA set priorities in considering broad categories of pesticides such as organophosphates, and speed the pace of decisions on pesticide safety. Committee members representing environmental/consumer organizations and farmworkers are Sara Lynch, World Wildlife Fund; Carolyn Brickey, National Campaign for Pesticide Policy Reform; Ken Cook, Environmental Working Group; Jeannine Kenney, Consumers Union; John Adams, Natural Resources Defense Council; Marion Moses, Pesticide Education Center; Nelson Carrasquillo, C.A.T.A.; and Shelley Davis, Farmworkers Justice Fund.

Members representing agriculture and farmers are Bill Spencer, Yuma, AZ; Brad Luckey, Imperial County, CA; Dan Botts, Florida Fresh Fruit and Vegetable Association; Wally Ewart, Northwest Horticultural Council; William Lovelady, National Cotton Council; Jim Czub, National Corn Growers Association; Larry Elworth, Program for Strategic Pest Management; Charles Mellinger, NAICC; Robin Spitko, Plant Pathologist; and Steven Pavich, Terra Bella, CA. A list of all members is available from EPA at (202) 260-4355.

Scientists Believe Earth is in Midst of Mass Biological Extinction

Seven out of ten biologists believe that "we are in the midst of a mass extinction of living things, and that this loss of species will pose a major threat to human existence in the next century," according to a nationwide survey by the American Museum of Natural History in New York City, conducted by Louis Harris and Associates. The survey interviewed 400 experts in the biological sciences who are members of the American Institute of Biological Sciences. According to the scientists' estimates, this mass extinction is the fastest in the earth's history. Unlike prior extinctions, this "sixth extinction" is mainly the result of human activity, and not natural phenomena.

According to the survey, scientists identified the key causes of this extinction as the increasing human population and the rate at which humans consume resources. They said those problems cause a loss of biodiversity through habitat destruction and degradation, overexploitation of plant and animal species, introduction of non-native species into habitats, pollution and contamination, and global warming. In the survey, scientists identified the maintenance of biodiversity as critical to human well-being, and rated biodiversity loss as a more serious environmental problem than the depletion of the ozone layer, global warming, or pollution and contamination.

Taking a pragmatic behavioral approach to alternative agriculture research

Leslie Aileen Duram

Abstract. *This article seeks to stimulate thought on the philosophy behind agricultural research. Pragmatism is identified as a philosophical basis for studying environmental issues that focus on human behavior. The ways in which this approach is applicable to the study of alternative agriculture are illuminated. "Behavioral pragmatists" differ from "behavioral positivists" in their aim, focus, process, and approach to research. I describe the main goals of the pragmatic behavioral approach: accepting a systems approach to study the interrelationships between humans and the environment; gaining understanding through human experiences; viewing problems as whole complex "problematic situations"; and promoting social activism and appropriate policy formulation. Combining qualitative and quantitative methods is often most effective. Pragmatism allows for holistic analysis that incorporates numerous factors that influence human uses of the environment. A specific example shows how behavioral pragmatism is effective in research on alternative agriculture.*

Key words: pragmatism, behavioral research

Human impacts on the environment are often studied primarily as either "social" or "ecological" because most researchers frame their questions in this segregated manner. Within agricultural land use, for example, lines are often drawn between social and ecological research. This division is widened by the traditional paradigm split between natural and social sciences, an enduring obstacle to integrative research (Blaikie, 1985).

Efforts to integrate the physical and social aspects of environmental studies are needed, as are new research paradigms that incorporate aspects of both positivism and pragmatism. Positivism draws on the scientific method and empirical methods of research, while pragmatism is based on understanding human experience. Alternative agriculture is a specific area in which to develop these ideas. Agriculture is a productive enterprise, an extractive activity, and a way of life based on one of the most integrated relationships between humans and their environment. Of the many human activities that affect nature, agriculture has been the most pervasive cause of large-scale biophysical change of the landscape (Jackson, 1980; Bennett and Dahlberg, 1990). Both social and ecological factors are pervasive in agricultural decision making, and thus must be studied in an interrelated way.

Human and physical aspects of agriculture can be integrated through individual farmers' environmental perceptions and associated land use decisions that influence and are influenced by the natural environment. Behavioral research illuminates individual characteristics (e.g., attitudes, knowledge, experience, behavior) that describe people's decisions and how they affect the local environment. When used toward pragmatic ends, such research can stimulate social activism and policy initiatives that encourage ecologically sustainable land use decisions.

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Studying People's Behavior

Behavioral approaches emerged in the 1960s out of a dissatisfaction with the positivists' methods and normative models. Early behavioral research, however, did not sever its ties with the previous paradigm. Wolpert (1964), for example, employed descriptive behavioral theory to explain farmer decision making in Sweden, but remained very much within the positivist paradigm. He statistically compared all farmers' choices to a "rational" model in which high productivity and high income were the ultimate goals. He explained lower productivity and income solely as a sign of farmer "maladjustment" (Wolpert, 1964, p. 557). Although the positivist approach would have remained appropriate for his research design, he chose a partially behavioral approach, yet omitted personal factors and concepts of stewardship, which are important in explaining agricultural behavior.

More recently, behavioral approaches have widened the scope of social sciences by emphasizing the value of understanding individuals in addition to ecological, political and social structures. But regardless of the original reason for its development, much behavioral research remains within a positivist paradigm. People are still commonly placed in "neat" boxes when they respond to survey questions. Researchers still begin with a preconceived theory and seek to prove their hypothesis, even though human decision making is complex and affected by numerous influences. The commonly accepted notion of a "random stratified sample," for example, is value-laden and creates analysis determined by categories that are established in advance by the researcher. The categories could

omit important aggregate groups, who would then be excluded from the analysis and results.

One subfield of environmental research is associated with the work of Gilbert F. White and his students. This field, often termed "natural hazards," encompasses a broad range of natural resource and environmental studies. This research is distinct from other behavioral approaches because of its philosophical basis, which is drawn from the pragmatic tradition. Pragmatism is concerned with understanding and resolving problems that occur in our uncertain world. Thus pragmatists acknowledge that their inquiry will not lead to certainty because nothing in the world is certain. According to William James, a central figure in this philosophy, a pragmatist "turns away from abstraction and insufficiency, from verbal solutions, from bad *a priori* reasons, from fixed principles, closed systems, and ... the pretense of finality in truth" (James, 1907, p. 51). Instead, a pragmatist "defines meaning and knowledge in terms of their function in experience" (Beck, 1969, p. 515). An underlying pragmatic concern among some behavioral researchers is the importance of dealing with problems in the real world.

Pragmatists and Positivists

While a behavioral approach has potentially broad appeal in natural resource management, land use, and human impact studies, it has left many scholars and students searching for a theoretical basis (Boal and Livingstone, 1989; Emel and Peet, 1991). As a participant in this theoretical exploration, I have discovered that there are at least two distinct realms of behavioral research. In the following, I describe "behavioral positivism" and "behavioral pragmatism." I contrast these two approaches in order to clarify their philosophical bases, but there clearly is potential for merging and overlapping them.

Both behavioral pragmatism and behavioral positivism evolved out of dissatisfaction with positivist approaches, but their focus, process, and aims differ (Table 1). First, behavioral positivists conduct more theoretical, abstract studies (Golledge, 1981, p. 328). Behavioral pragmatists, on the other hand, believe that research should be used as a means of problem solving and for the promotion of human welfare (Frazier, 1981). Many behavioral pragmatists would agree with the opinion of Gilbert F. White (1972, p. 103):

> I feel strongly that I should not go into research unless it promises results that would advance the aims of the people affected and unless I am prepared to take all practicable steps to help translate the results into action.

This statement indicates the extent to which pragmatists aim to conduct research whose results are easily translated into practical—often policy oriented—ends. Academic research can be constrained by oppressive objectivity, which leads to the separation of much research from practical policy suggestions. The aim of behavioral pragmatism, however, is to understand the multiple factors involved in people's actions in a given situation (Castle, 1996). Environmental topics are particularly conducive to such applied goals, because natural resource management, environmental policy, and agricultural land use invite practical action.

Behavioral pragmatists focus on an individual decision maker within an actual natural resource situation. The problem, issue, or conflict is perceived in its broad context. This leads to research inquiry in an attempt to better understand and ultimately solve a human problem, which can result in policy or social change. Behavioral positivists, on the other hand, study individuals in various settings, seeking to create an objective model to explain a given topic. The positivists are thus deductive, moving from theory to the development of hypotheses in order to study a specific problem, while pragmatists are inductive, moving from a complex problem to a general theory of understanding in order to improve a given situation.

Table 1. Differences between two types of behavioral research

Contrast Area	Behavioral Research (focus on individuals)	
	Behavioral Positivism	**Behavioral Pragmatism**
Philosophy	no single philosophy	pragmatism basis
Focus	abstract; varies	actual human problems
Approach	hypothesis testing on certain topic	problematic situation leads to questions
Process	deductive theory→hypotheses→problems	inductive problem→theory
Aims	seek "objective" research build theories; models	seek understanding improve policies

Pragmatic Research Goals

I will describe four pragmatic behavioral goals that can guide researchers: 1) accepting chaos in the interrelationship between humans and the environment; 2) seeking an understanding based on human experience; 3) viewing a problem as a complex *problematic situation*; and 4) promoting activism and policy formulation. These goals are built upon notions developed by Light and Katz (1996) and by Wescoat (1987; 1992), who described pragmatism in environmental research and geography. After outlining these pragmatic behavioral goals, I will specifically describe their applicability to the study of alternative agriculture.

First, society and nature are interdependent, and nature provides uncertainty that people define and attempt to resolve. Pragmatism accepts this notion of the precariousness of nature and assumes it is a real feature of every situation, according to pragmatist John Dewey (1958). To address current ecological problems, which often are an outcome of our attempts to control nature, pragmatism accepts the premise that nature is basically unpredictable. Chaos, according to Gleick (1987) is the irregular, discontinuous and erratic side of nature. Just as physical scientists question the suitability of linear prediction formulas for weather forecasting (Lorenz,

1984), social scientists theorize that interactions between society and the environment have a chaotic relationship (Merchant, 1992). Behavioral pragmatism allows for such views by accepting a systems approach to our individual and societal relationships with nature. This provides research freedom, since pragmatism does not require a narrow investigation that seeks one resultant "truth."

A second goal of the pragmatic behavioral approach is to embrace human experience as a fundamental link in environmental decision making. According to Dewey, experience is what we do, how we learn, and what happens to us (Dewey, 1958; Thayer, 1970). Pragmatist Charles Peirce noted that we should look at general long-term effects and experiences, not just short-term specific ones (Harshorne and Weiss, 1931). Further, knowledge is valued for its usefulness, and understanding of a situation must be gained through one's own experiences or inferred from other people's experiences (Charon, 1979). Pragmatism focuses on tangible human situations, as opposed to abstractions. By investigating human behavior, we actually attempt to understand human experiences. Thus pragmatic inquiry is only instrumental, not an end in itself. The research aim is not to seek an absolute truth (because none exists), but to formulate policies and to aid in improving society. Abstract questions are asked only if they are directly relevant to a specific research case. Pragmatic behavioral research involves the study of human experience to understand the "truth" of what works best in a given situation.

Third, pragmatists seek to improve problematic situations rather than testing narrow research hypotheses removed from their contexts. Pragmatic behavioral research views an environmental problem not as an isolated event, but rather in its full context. This problematic situation is investigated through "decision elements" (e.g., social, technological, ecological, economic, perception, and spatial factors) that can be explored concurrently and interactively. This is linked to the "range of choice" concept commonly described in natural resource decision making (White, 1961). There is no fixed progression, and new elements may be discovered to define the problem better. Qualitative techniques are complementary to quantitative methods and are effective in searching out the complexity of human behavior (Miles and Huberman, 1994). A pragmatic researcher seeks to transform a problem by investigating its complex interrelated elements to understand the entire situation better. The goal is to present alternatives and to take appropriate action. This should lead to social activism and appropriate policies.

Many problems, and thus many research questions, are firmly embedded in our society, so the pragmatic aim of transforming a problematic situation often confronts the status quo. Pragmatic approaches acknowledge that scholars may need to confront "entrenched social constraints" (Wescoat, 1992, p. 596). This leads to the fourth goal: to contribute a unique perspective that links individual decision making to societal change through public participation. Academic inquiry can inform public choice, if research is practical and applied to issues in the real world. A pragmatic behavioral approach can provide a link to radical environmental philosophies (e.g., ecofeminism, deep ecology, the Greens) through an emphasis on individual decision makers at a grassroots level acting to promote environmental policies and social change. Behavioral pragmatists do not stress class, gender, or race differences, but rather seek to encourage each individual to be informed and take part in a truly democratic process. Indeed, pragmatists like Dewey stress that our democratic society requires diversity and a complex understanding of the world (Alexander, 1995). Pragmatic behavioral research seeks to understand and reinforce individual people's capacities for action. Individual and community empowerment can improve a problematic situation and eventually can lead to an improved society.

Behavioral Pragmatism in Agriculture

While few deny the productive strengths of the current U.S. farming system, its ecological and social dimensions are increasingly criticized. We must question the sustainability of industrial agricultural techniques manifest in the degradation of water quality, soil fertility, and ecosystem processes (Hallberg, 1987; Soule and Piper, 1992; Zaring, 1996). Social concerns are raised by those who believe that an agricultural system with many small family farms is more socially sustainable than one with fewer but larger agribusiness operations (Berry, 1986; Goering et al., 1993; Smolik et al., 1995). Others fear for worker safety and the safety of a food supply produced with toxic synthetic chemicals (Clancy, 1990; Jacobson et al., 1991; McDuffie et al., 1995).

Arguments from these perspectives reveal a broad problematic situation—the unsustainability of industrialized agriculture. Pragmatism sets the stage for an inclusive view of the situation, and raises questions that integrate ecological and social concerns: What might U.S. agriculture look like in the future? What changes are now occurring in the relationships between people and the land? Attempts to answer these questions may fall within behavioral research, and a pragmatic behavioral approach would broaden the questions to understand real world agricultural decision making.

The four goals of pragmatic behavioral research are particularly applicable to agricultural research. Farming is tied to our perceptions of and ability to work within the natural system. The pragmatic behavioral approach accepts chaos and uncertainty in nature and seeks to expand the scope for human adjustment. Thus, notions of sustainable development and questions of short-term versus long-term interaction with nature can be encompassed fully. For example, the use of pesticides may control pests for the short run, but can lead to long-term problems, including pest tolerance and nonpoint-source water pollution. Pragmatism acknowledges that long-term control over the environment is not possible because human and physical systems are constantly in flux and their interrelationship is based on delicate balances within a dynamic system. Humans must adjust and develop a sustainable relationship with nature. The pragmatic behavioral approach does not seek judgment; rather, it seeks to learn what has occurred already, what is happening now, and what adjustments are possible.

Individual farmers' experiences provide insight into the current agricultural system. Without investigating these experiences, we can obtain only cursory information. But we must seek to investigate farmers' characteristics and decision making fully, rather than employing survey methods that place farmers into specific categories from the outset. Qualitative techniques are complementary to quantitative methods and are effective in discovering a fuller, richer view of farmers' everyday actions (Miles and Huberman, 1994). Pragmatic inquiry within an agricultural context encourages deep questioning of our current system of industrial agricultural production. Critics question the sustainability of industrial agriculture. Understanding farmers' characteristics and attitudes associated with the adoption of conservation methods will identify the actual course of action taken by some farmers. This would lead to a better understanding of the system-wide transition toward sustainable agriculture, which could help in creating appropriate agricultural policies. Historically, the U.S. has drawn on the importance of individual family farms and a populist movement based on rural ideals (Kloppenberg and Geisler, 1985; Nash, 1990). However, much current agricultural research has assumed that a viable production system must be based on large-scale industrial farming. Pragmatic behavioral research can address the complex problems caused by clashes between historical ideals and the current agricultural system.

A Pragmatic Behavioral Study: The Adoption of Alternative Agriculture

While policy and research often support the conventional agricultural system at the expense of alternatives, the pragmatic behavioral approach encourages the study of true alternatives, such as organic farming, permaculture, and cooperative community-based agriculture. Alternative agriculture is a link between individuals, society, and the environment.

The "experimental method," according to Dewey, is a pragmatic means of incorporating flexible and pluralistic methods that best fit a specific research subject (Alexander, 1991). I present a brief overview of methods and results of a pragmatic behavioral study I conducted in Colorado in 1994 (Duram, 1997). The study began with recognition of a problematic situation—the unsustainability of U.S. agriculture. Relevant questions emerged, including: What factors influence farmers who adopt alternative methods? Who are these farmers? How do they make the transition to alternative agriculture?

A survey of nearly 150 farmers was conducted to investigate operational characteristics, demographic variables, decision-making factors, and attitudes on ecology, technology, scale of production, and agricultural idealism. I analyzed data obtained from mail questionnaires from more industrial and more alternative farmers. Univariate quantitative analysis provided a cursory definition of several groups of farmers. I also conducted in-depth, multiday interviews of case study farmers; qualitative analysis of interview data revealed deeper motivations behind farmers' decisions to adopt alternative methods.

The questionnaires and interviews were philosophically based on the four goals of pragmatism. First, the pragmatic acceptance of chaos in nature involved investigation into farmers' perceptions of risk and their relationship to the environment. I discovered that certain characteristics were present, to varying degrees, among the farmers. These included personal and perceptual factors such as: seeking challenges, acceptance of risk, openness to outsiders and new ideas, trust in one's own farming experience, and feeling in control of one's own operation. Operational factors also dealt with the acceptance of chaos: cropping diversity, participation in government programs, and marketing strategies. Although each farmer is unique, a pragmatic analysis helps me understand how these characteristics differ between groups of industrial and alternative farmers.

Second, the study considered how farmers draw from their experiences and those of other farmers to make informed decisions. In conversational interviews with farmers, it was obvious that multiple factors influence their decision to adopt or reject alternative methods. These subtle and varying traits might not have been discovered if narrow positivist methods had been employed. Third, I investigated the problematic situation (i.e., agricultural sustainability) through an understanding of farmers' individual solutions and adaptations. Farmers shared their experiences and described their personal attempts at rectifying the problems they perceived. Their actions included the adoption of chemical-free agriculture, soil conservation methods, social activism, and numerous other actions.

Fourth, I addressed the notion of activism and policy change by investigating how individual farmers independently gather information, decide to adopt alternative methods, and seek alternative marketing and distribution channels. This information could assist agency personnel in identifying appropriate educational and policy initiatives to reach farmers. Further, in alternative production, individual farmers overcome ingrained social structures by confronting generational values, identifying unconventional markets, and seeking alternative sources of information. The pragmatic behavioral approach seeks to understand and reinforce individuals' capacities to take action, so my research viewed individuals as the necessary component for change in U.S. agriculture.

This example of alternative agriculture is just one application of a pragmatic behavioral approach. Numerous environmental topics provide rich problematic situations for study (e.g., local environmental activism, land use policies, attitudes about rural sustainability, public lands conflicts).

Conclusions

A pragmatic behavioral approach can jointly address environmental and social perspectives that allow us to investigate human experience, human adjustment to natural processes, and the subsequent range of choice that individuals and society identify. Pragmatic researchers should speak publicly to raise concerns, inform people, and encourage cooperation. In addition, this approach is particularly valuable at a grassroots level for encouraging ideas and movements regarded as outside the mainstream.

For more researchers to employ behavioral pragmatism, it must be recognized as a valid philosophical approach for the

social sciences. Most adherents to this approach prefer to spend their time on applied research projects that deal with human problems, rather than partaking in debates on philosophical/theoretical concerns. This may explain why behavioral pragmatism has not been embraced in the social sciences. Researchers should be aware of and use a pragmatic behavioral approach to address complex environmental issues.

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USDA Abandons Three Contentious Issues in Proposed Organic Standards

Responding to 200,000 "extraordinary" public comments, the USDA abandoned its proposal to include the products of genetic engineering, irradiation, and municipal sewage sludge in organic food production, which had been part of the national organic standards the agency proposed late last year. "USDA is committed to developing national organic standards that organic farmers and consumer will embrace," said USDA Secretary Dan Glickman. "Thousands of commenters requested that USDA issue revised proposed standards, and we intend to do so. The revised proposal will contain fundamental changes from our initial draft."

According to Newsweek (June 1, 1998), "The USDA yanked the proposal back for a rewrite after it took an unprecedented public beating. Some 200,000 people wrote, faxed, e-mailed or spoke up at public hearings to let the USDA know they overwhelmingly rejected the standards, especially if they allowed what became known as the Big Three to be sold as organic: genetically engineered food, irradiated food and food grown in municipal sewage sludge."

USDA also said that many of the public comments asserted that national organic standards must be rigorous and credible. Otherwise, commenters expressed concern that consumers will lose faith in the organic label. "If organic farmers and consumers reject our national standards, we have failed," Glickman said. USDA will evaluate the public comments on the initial proposal and publish the revised proposal later this year.

Newsweek's three-page article asks, "Is there any reason at all to pay extra for organic? Sure....A USDA report documents numerous examples of the environmental threat posed by farm chemicals, including the destruction of fish, wildlife and beneficial insects. Farm workers who apply pesticides and herbicides have disproportionately high rates of some cancers -- and so do their children." From an environmental point of view, "the lower price tag on conventional produce may be deceptive," according to the article, which argues that "our food supply only seems cheap because its real costs aren't represented by supermarket bar codes." Once the final USDA regulations are in place, by about 2000, "shoppers who choose organic will know for the first time exactly what they're buying."

According to comprehensive public comments filed by the Wallace Institute, the proposed national organic standards were "fatally flawed" and "must change substantially." The Institute's comments covered every aspect of the proposed standards for the national organic program and filled 125 pages. Among the key points made in the comments were:

- The program should better reflect a public-private partnership by providing more authority to existing state and private certification organizations.
- The proposal disregards the authority granted to the National Organic Standards Board (NOSB) to determine the materials that may be placed on the National List of allowable synthetics in organic production. The Institute's comments advise the USDA to uphold that authority, a view reflected in a legal memorandum written by the Wallace Institute and submitted as an official NOSB document to the USDA Secretary, which provides a solid legal argument for upholding the Board's authority to determine the National List.
- The USDA should delete its proposed addition of genetically engineered organisms, ionizing radiation, and biosolids as acceptable materials, and follow the NOSB recommendations severely limiting the use of National List materials.
- The program should include a progressive fee structure that takes into account the size of farm, handling, and certification operations. The proposal does not account for differences in the size of farms or certification agents.
- The proposed rules on livestock fail to meet international standards or industry expectations. The Institute recommended revisiting every component of the livestock proposal.
- The proposed prohibition on eco-labeling should be deleted; the USDA should defer eco-labeling concerns to the Federal Trade Commission, which has been monitoring the issue.

As the next step, the Wallace Institute recommended submitting a re-proposal to the Federal Register by October 1, 1998, to allow sufficient time for USDA staff to analyze the public comments and make necessary adjustments. It also recommended a comment period on the re-proposal of at least 90 days, which would allow final rules to be published in the Federal Register in the spring of 1999, with a goal of final implementation in the growing season of 2000. Rewriting the proposal should not be overwhelming and would lead to popular support, if the new rules reflect the NOSB recommendations, the Institute wrote.

"Everyone understands the headlines about the proposal, so now let's roll up our sleeves and get to work on the details so we can have a program in place by 2000," said Kathleen Merrigan, the Wallace Institute's Senior Analyst and a member of the National Organic Standards Board. "The vast majority of public comments urged the Secretary to adopt the NOSB recommendations."

UPCOMING EVENTS

July 23, Milan No-Till Crop Production Field Day and Research Tours will be held in Milan, TN; contact Dr. Blake Brown, Milan Experiment Station, 6505 Ellington Drive, Milan, TN 38358; (901) 686-7362; e-mail utmilan@usit.net

July 29, "Tools for Transitioning" Field Day will be held in Holtwood, PA; contact Steve Groff, Cedar Meadow Farm, 679 Hilldale Road, Holtwood, PA 17523; (717) 284-5152; e-mail sgroff@epix.net; information is available on the Internet at http://www.cedarmeadowfarm.com

August 13-21, "Permaculture Fundamentals for Women" will be held at Culture's Edge, 1025 Camp Elliott Road, Black Mountain, N.C. 28711; (828) 298-2399; e-mail culturesedge.earthaven.org

August 5-9, "Beyond Politics: Rethinking the Future of Democracy," the 61st Annual Meeting of the Rural Sociological Society, will be held in Portland, OR; contact JoAnn Jaffe, Program Chair, Dept. of Sociology/Social Studies, University of Regina, Regina, SK S4S 0A2, Canada; (306) 585-4198; e-mail joann.jaffe@uregina.ca

August 7-9, 24th Northeast Organic Farming Association Summer Conference will be held in Amherst, MA; contact NOFA, 411 Sheldon Road, Barre, MA 01005; (978) 355-2853.

August 10-14, "Ecology and Design: Northeastern Landscapes," and August 21-23, "Selecting a Native Plant Palette: Using Native Plants in Public and Private Landscapes" will be held at Conway School of Landscape Design, P.O. Box 179, Conway, MA 01341; (413) 369-4044; e-mail workshops@csld.edu

August 14-16, "HerbFest'98" will be held in Norway, IA; contact HerbFest '98, P.O. Box 299, Norway, IA 52318; 1-800-669-3275.

September 9-10, "It's Just Common Sense: Practical Approaches to Better Groundwater Management," the 14th Annual Groundwater Foundation Fall Symposium, will be held in San Antonio, TX; contact the Groundwater Foundation, P.O. Box 22558, Lincoln, NE 68542; e-mail susan@groundwater.org

September 10, Thompson On-Farm Research Field Day will be held at the Thompson Farm, Boone, IA; contact Dick and Sharon Thompson, 2035 190th St., Boone, IA 50036; (515) 432-1560.

RESOURCES

"Agroforestry: Agriculture and Forestry Working Together," a 59-minute video, is available on loan from the National Agroforestry Center, USDA FS/NRCS, East Campus-UNL, Lincoln, NE 68583-0822; (402) 437-5178; on the Internet, http://www.unl.edu/nac

"Food Production And Environmental Stewardship: Examples of How Food Companies Work With Growers" is available from Richard Kashmanian; Office of Policy Development; Office of Policy, Planning, and Evaluation (2128); U.S. EPA, 401 M St., SW, Washington, D.C. 20460; e-mail kashmanian.richard@epamail.epa.gov

"Investing in the Future of Agriculture: The Massachusetts Farmland Protection Program and the Permanence Syndrome" is $14.95 plus shipping/handling from American Farmland Trust at 1-800-370-4879.

"Growing Vegetables in Wisconsin," a series of five publications with different prices, is available from University of Wisconsin Cooperative Extension Publications, (608) 262-3346.

"Organic Certification of Crop Production in Minnesota" is $3 plus $2 shipping from University of Minnesota Extension Service, Distribution Center, 1420 Eckles Ave., St. Paul, MN 55108; 1-800-876-8636.

"Northeast Aquaculture: Farming the Waters," a 30-minute video, $10; **"Facilities for Roadside Markets,"** 32 pages, $10.50; and **"Guide to Great Forestry and Natural Resources Publications,"** a publication of 1,300 resources, $13.50, are all available from Northeast Regional Agricultural Engineering Service, (607) 255-7654; e-mail nraes@cornell.edu

"Eco-Labels: The Key to Consumer Support" is $35 from The Food Alliance, 1829 NE Alberta St., #5, Portland, OR 97211; (503) 493-1066; e-mail tfa@thefoodalliance.org

California Federation of Certified Farmers' Markets lists 350 farmers' markets on the Internet at http://farmersmarket.ucdavis.edu; for information, contact Susan McCue, UC Small Farm Center, (530) 752-7849; e-mail semccue@ucdavis.edu

"Urban Agriculture: An Abbreviated List of References and Resource Guide" is available from Alternative Farming Systems Information Center, National Agricultural Library, ARS, USDA, 10301 Baltimore Ave., #304, Beltsville, MD 20705; (301) 504-6559; or on the Internet at http://www.nal.usda.gov/afsic

"The Future Agenda for Organic Trade," proceedings of the 1997 Organic Trade Conference, are $30 from IFOAM, fax +49-6853-30110, or e-mail ifoam@T-Online.de

"Sustaining Profits and Forests" is $10 from Island Press, Box 7, Dept. 2AU, Covelo, CA 95428; 1-800-828-1302; e-mail ipwest@igc.apc.org; on the Internet, http://www.islandpress.org

Four films: "An Introduction to Ecological Economics" ($25); **"Investing in Natural Capital"** ($29.95); **"Conversation for a Sustainable Society"** ($25); and **"Costa Rica Counts the Future"** ($39.95) are available from Grieslinger Films, 7300 Old Mill Road, Gates Mills, OH 44040; 1-800-872-4456; e-mail Prgfilms@ix.netcom.com

"Time for a Change: Pesticides and Wine Grapes in Sonoma and Napa Counties, California" is $5 plus $2 shipping from Californians for Alternatives to Toxics, P.O. Box 1195, Arcata, CA 95518; (707) 822-8497; e-mail cats@igc.org

Guide for Authors

The American Journal of Alternative Agriculture (AJAA) publishes original research on biological, physical, or social science aspects of alternative agriculture. We particularly welcome multidisciplinary studies, but papers from a specific discipline also are invited. However, since AJAA readership is much broader than for a single-discipline journal, highly specialized terminology should be explained or avoided. The significance of a statement, or the reasoning behind a conclusion, may have to be spelled out more than in a more specialized journal. See Vol. 5, No. 1, pp 2 & 3, for an explanation of the various categories of articles.

Units

Research papers should use the International (SI, or metric) system throughout. Occasional use of common unit equivalents in parentheses is permitted.

Title page

The title page should give the following information (all flush left): 1) title of the paper; 2) names of the authors; 3) affiliation and office address of authors, and 4) disclaimers and publication number, if any. See examples in this issue of AJAA.

Abstract

The abstract should be 200 to 400 words suitable for readers from a broad range of disciplines. It should avoid highly-specialized terminology that might be appropriate for a single-discipline journal. Take particular care that the significance of the work is made clear, even to readers from a different field.

Key Words

Provide subject matter key words suitable for use in scientific indexing.

Reference List

When citing material that has been covered in more than one format, such as the typescript of a conference presentation and a journal article, preference should be given to the version that is most readily available, and that is likely to remain so. Generally this means standard publication channels, such as books, journals, and regular government report series. Unpublished or informally-published material should be cited only when no alternative form exists.

References should be listed in alphabetical order by author's name, and by year for a particular author (with letters after the year if needed). If a sole author is also the lead author of papers with multiple authors, use the following order: single author (by year); two authors (alphabetically by second author's name); three or more authors (by year). Repeat the author's name for each reference. Give the names of all authors in the reference; never use "et al."

Use full names of journals, institutions, conferences, etc., except for extremely familiar abbreviations like "Dept." Remember that an abbreviation familiar to you may not be familiar to readers outside your field. If in doubt, write it out.

The reference list uses no quotation marks, italics, boldface, or underlining. Only the names of books and periodicals are in initial capitals. Names of papers, book chapters, pamphlets, and bulletins are not capitalized.

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Cite references in the text by last name and year, with chapter or page numbers if the reference is a book or lengthy report. For two authors, give both names. Do not use "et al." unless there are at least three authors.

Footnotes

AJAA does not use bibliographic or substantive footnotes. All bibliographic references should be at the end of the text. Instead of substantive footnotes, include the material in the main text or consider eliminating it.

Manuscript Preparation

The entire manuscript, including abstract and references, should be typed on one side of standard-size paper, double spaced, with margins of at least one inch all around. Starting with the title page, label all pages in the upper righthand corner with the lead author's last name and the page number. Do not use hyphens unless the hyphen is part of the word.

Tables should fit on one page, be numbered consecutively with Arabic numerals, and be on a separate sheet. Every figure and table should be mentioned at least once in the text.

A detailed guide to formatting is available from the editor (address below).

Submission of Manuscripts

Submit four high-quality copies to Dr. Robert I. Papendick, Editor, American Journal of Alternative Agriculture, Department of Crop & Soil Science, 253 Johnson Hall, Washington State University, Pullman, WA 99164-6420. The cover letter should state that the manuscript is an original contribution that has not been published elsewhere in substantially the same form, that it is not currently under consideration elsewhere, and that permission has been obtained for any copyrighted material used.

How you can help support the scientific and educational needs of a sustainable agricultural system

A growing number of Americans have become concerned about the long-term sustainability of our food production system. Farmers and agricultural scientists are among those raising questions about the growing dependence of modern farming on nonrenewable resources, the depletion of our resource base through soil erosion, and heavy reliance on chemical fertilizers and pesticides. Continued heavy reliance on farm chemicals is questioned because they have become an expensive production input. Their widespread use also raises questions about human and animal health, food quality and safety, environmental quality, and the continued demise of family farms and rural communities.

Alternative farming methods address these economic and environmental challenges. Alternative production systems point the way toward more profits, more individual choice, enhanced environmental quality, and long-term sustainability for our food system. More must be done to develop effective ways to make sure research, education, and information sources are readily available to farmers who want to adopt these techniques.

The Henry A. Wallace Institute for Alternative Agriculture needs your help in meeting this challenge. We are a nonprofit tax-exempt research and education organization established in 1983 to encourage and facilitate the adoption of low cost, resource conserving, and environmentally sound farming methods. We work directly with government agencies, colleges and universities, producer groups, and other institutions that provide research, education and information services to farmers.

The Wallace Institute also provides these services:

- *A resource to lawmakers and others who influence agricultural research, education, and information policy*
- *A voice for alternative agriculture in Washington*
- *A sponsor of research and education outreach programs*
- *A national clearinghouse for information on alternative agriculture*
- *A publisher of reliable scientific information on agricultural sustainability*

If you're interested in helping us, please contact the Henry A. Wallace Institute for Alternative Agriculture, 9200 Edmonston Road, Suite 117, Greenbelt, Maryland 20770-1551. Telephone: 301-441-8777; E-mail: hawiaa@access.digex.net; Web site: www.hawiaa.org

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